EXPERIMENTAL

ESSAYS

[redacted] ON [redacted]

MEDICAL and PHILOSOPHICAL

SUBJECTS:

[redacted] PARTICULARLY, [redacted]

I. On the Fermentation of Alimentary Mixtures, and Digestion of the Food.

II. On the Nature and Properties of Fixed Air.

III. On the respective Powers, and Manner of Acting, of the different Kinds of Antiseptics.

IV. On the Scurvy; with a Proposal for trying new Methods to prevent or cure the same, at Sea.

V. On the Dissolvent Power of Quick-Lime; and a further Investigation of the Properties of Fixed Air.

The SECOND EDITION, ENLARGED and CORRECTED.

Illustrated with COPPER-PLATES.

By DAVID MACBRIDE, M.D.

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M,DCC,LXVII.

ERRATA.

In Page 38. In the Note, for *du Harnel*, r. *du Hamel*.
—— 46. Line 16. for Page 34, r. Page 25.
—— 111. Note, for Putrefaction, r. Fermentation.
—— 169. Line 11. for Page 174, r. Page 134.

DIRECTIONS to the BINDER.

Place Figure 1.	Opposite to Page	25.
—— 2.	——	39.
—— 3.	——	55.
—— 4. & 5.	——	179.

The wonderful and ſecret Operations of Nature are ſo involved and intricate, ſo far out of the Reach of our Senſes, as they preſent themſelves to us in their natural Order, that it is impoſſible for the moſt ſagacious and penetrating Genius to pry into them, unleſs he will be at the Pains of analyſing Nature by a numerous and regular Series of Experiments, which are the only ſolid Foundation whence we may reaſonably expect to make any Advance in the real Knowledge of the Nature of Things. *Hales.*

THE

PREFACE.

THE general purpose of the following essays is to shew, that there is a principle in matter which, hitherto, has not been much attended to; and that this principle, forming the cement, or bond of union, among the insensible particles, is to be held as the immediate cause of firmness and perfect cohesion in those bodies, wherein it enters the composition, and is to be regarded as the thing that prevents their dissolution and decay.

It being the author's intention to apply this doctrine particularly to medicine, he begins his investigation by tracing the progress of digestion, and shewing that the principle above hinted at, is received into animal bodies, by the way of the chyliferous canals; and this makes up the subject of the first essay, and of some part of the second.

THIS

THIS point being proved by a number of experiments, and illuſtrated by ſome practical obſervations, he goes on to ſhew, from experiment alſo, that animal ſubſtances become putrid from the loſs of the above-mentioned principle; ſeeing, that putrefaction is found to ariſe from the reſolution and diſunion of the ſeveral conſtituent particles; and offers a new theory for explaining the immediate cauſe of that degree of putrefaction, which often takes place in the living body. Here an opportunity is taken of introducing ſome experiments in order to determine whether or not putrid animal ſubſtances are to be regarded as alcaline: and it appearing from theſe that ſuch ſubſtances are in reality of an alcaline nature, and that ſome writers of very great note have been miſ-led into a contrary opinion, probably from obſerving that alcalies reſiſt putrefaction; he then proceeds, in the third eſſay, to examine, experimentally, the power of antiſeptics in general; and finds that this depends, for the moſt part, on reſtraining the flight of the cementing principle.

AN enquiry then commences concerning the power of different things to reſtore ſoundneſs and ſweetneſs to ſubſtances already putrid; and it is ſhewn, likewiſe from experiment, that this may be accompliſhed

plished by reſtoring the cementing principle.

This naturally leads to a conſideration of the moſt effectual methods of curing putrid diſeaſes, which is alledged to depend greatly on the application of ſuch things as are known to be capable of furniſhing a large proportion of the principle ſo often mentioned; and this is particularly exemplified in the cure of the ſea-ſcurvy; a diſeaſe wherein the maſs of fluids is evidently in a ſtate of putrefaction.

In conſequence of this hypotheſis, a propoſal enſues for trying new methods to prevent or cure the ſcurvy, at ſea; and this affords matter for a fourth eſſay, to which is annexed a very accurate account of that moſt deſtructive diſeaſe, extracted from the writings of John Woodall, an old Engliſh ſurgeon, whoſe works ſeem to be but very little known.

The fifth eſſay contains a number of miſcellaneous experiments and obſervations, all tending to a further proof of what had been advanced in the four precedings ones; and, moreover, lays down eaſy and expeditious methods of diſſolving, in water, camphor, and all kinds of reſinous ſubſtances.

The foundation of the foregoing doctrine having been laid near forty years ago, by the celebrated Doctor Hales, and, of late, much improved by Doctor Black, (late

(late Profeſſor of Medicine at Glaſgow, but now of Chemiſtry at Edinburgh) it will be proper that the reader be thoroughly acquainted with the Analyſis of Air, in the firſt volume of Hale's Staticks; and with the experiments on Magneſia, in the ſecond volume of the Edinburgh Phyſical and Literary Eſſays; as alſo with the experiments made by Doctor PRINGLE, and which are to be found in the Philoſophical Transactions, or in the Appendix to that learned phyſician's Obſervations on the Diſeaſes of the Army; the following papers being deſigned as a ſequel to all the three writers juſt now mentioned.

THE favourable reception of the firſt Edition, has engaged the Author to reviſe this in the moſt careful manner, and to make ſuch alterations and additions, as he hopes will render his labours ſtill more acceptable; particularly, there is an experiment added to thoſe of the ſecond eſſay, which may be looked on as concluſive with reſpect to the theory of putrefaction; and there are others added to the fifth, in order to illuſtrate further the properties of that principle, which is the general object of the whole performance.

IN the appendix to the fourth eſſay, there are ſome extracts of letters, and other papers concerning the methods propoſed for treating the Scurvy at Sea.

ESSAY I.

ON THE

FERMENTATION

OF

ALIMENTARY MIXTURES.

The main business of natural philosophy is to argue from phænomena, without feigning hypotheses. NEWTON.

THE old chemists believed, that all the true spontaneous changes of bodies, were the effects of fermentation; and *Boerhaave* once held the same opinion,* though he afterwards came to restrain it within very narrow limits, and would suffer nothing to be called Fermentation which did not produce either an ardent spirit, or an acid; thus entirely confining it to what are usually called the *vinous* and *acetous* stages, and altogether rejecting the *putrefactive*, as looking on putrefaction to be a quite different process, and no way allied to fermentation.

* Prælect. Academ. in Sect. 256.

BUT this reſtriction, which was meant for the ſake of clearneſs and preciſion, has rather introduced confuſion, with regard to the term putrefaction. This word, in its common acceptation, is always underſtood to imply a plain tendency to deſtruction in bodies, accompanied with every ſign of rottenneſs and offenſiveneſs: and, accordingly, we often meet with it in writers, in this ſenſe, when perhaps, in the very ſame page, we ſhall be told, that the aliment is prepared for nouriſhing the human body by putrefaction; that motion, life and heat are communicated to the fluids by putrefaction; and that nature throws off morbific matter from the conſtitution by the means of putrefaction.

THE later chemiſts, therefore, who have reduced this branch of natural philoſophy to a more intelligible and methodical ſyſtem, than that of the great man juſt now mentioned, approach nearer to the ancient opinion, and define fermentation to be an "*inteſtine motion, which ariſing ſpontaneouſly among the inſenſible parts of a body, produceth a new diſpoſition, and a different combination of thoſe parts.*"

FROM this definition, it is plain, that a great number of the natural changes which daily take place in the animal and vegetable kingdoms, ſhould be looked on as ſo many modes of fermentation; and that, in particular, the digeſtion of our food ought to be regarded as a fermentatory proceſs.

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THE experiments already made by the very learned and ingenious Dr. *Pringle*, ſeem ſufficient to convince every unbiaſſed reader of the truth of this theory; which, if we conſider the matter with any degree of attention, we ſhall find to be abſolutely neceſſary, in order to bring about that new diſpoſition, and that different combination, of the inſenſible parts of the alimentary ſubſtances which enable the immenſe variety of diſcordant mixtures that enter the compoſition of our food, to depart ſo far from their original natures as to become one mild, ſweet, and nutritious fluid; for this demands a great deal more than mere mechanical mixture and diſſolution, which is the moſt that the common theories * of digeſtion extend to; ſince they do not ſeem expreſly to require, nor indeed ſuppoſe, ſuch an abſolute change to be wrought, in the firſt paſſages, on the nature of the different kinds of food as would enable them to become, ſo ſoon as we ſee they do, one and the ſame ſubſtance with the body into which they are received.

IT alſo appears pretty plain, from Dr. *Pringle*'s experiments, that there is ſomewhat generated, or ſet free, during the *firſt ſtage* of the fermentation of animal and vegetable mixtures,

* Here we muſt except *Hoffman*'s theory; for he inſiſts much on the compleat change that the aliment undergoes in the firſt paſſages; and makes digeſtion a mere fermentatory proceſs; as may be ſeen at large in his chapter *de Alimentorum Solutione & Salivæ Uſu*, and the three ſucceeding ones.

tures, which hath a power of correcting putrefaction. But in order to obtain ſtill further proofs concerning this particular point, as well as to gain a more thorough knowledge of fermentation in general, I determined to repeat ſome of the doctor's experiments, and to try ſuch others as I thought had the greateſt tendency towards an illuſtration of both.

To fulfil theſe Intentions, I made up the ſix following mixtures:

1. Bread and water, about four ounces.

2. Bread and boiled mutton, beat up thin, with the requiſite quantity of water; in all about four ounces. This was called the ſimple fermentative mixture.

3. Four ounces of the ſimple fermentative mixture, with two drachms of freſh lemon-juice.

4. Four ounces of the ſimple mixture, beat up with an ounce of ſpinage.

5. Four ounces of the ſimple mixture, with an ounce of green water-creſſes.

6. Four ounces of the ſimple mixture, with two drachms of a very fetid liquor that lay about putrid mutton.

THESE mixtures, being put into phials not cloſely ſtopped, were all placed in a moderate degree of heat,* on the top of a ſand furnace, wherein a retort was at work, on a proceſs which

* The degree of heat in this, and in all the other experiments of the like ſort, was (as near as could be adjuſted) that of the human of body.

Table I. Of ALIMENTARY MIXTURES.

Mixtures of	At the end of 6 hours.	At the end of 22 hours.	At the end of 30 hours.	At the end of 46 hours.	After 54 hours.	At the end of 4 days.
(1) Bread and water.	Shews no ſign of inteſtine motion.	Still remains perfectly quiet.	Still at reſt.	Still at reſt.	Still at reſt.	A ſourneſs now perceivable.
(2) Bread, mutton, and water.	Fermentation fairly begun; ſmell of the mixture perfectly ſweet.	Fermenting now very briſkly.	Briſk; the ſmell of the mixture perfectly ſweet and a litttle pungent.	Briſk and ſweet; much froth at top.	Briſk and ſweet.	Fermentation appeared to be now very near over; liquor ſweet, both to the ſmell and taſte.
(3) The ſame, with freſh juice of lemons.	In briſk fermentation; perfectly ſweet; ſmell of the lemon juſt perceivable.	Very briſk; immerſed a ſmall bit of putrid mutton in this mixture.	Briſk; no ſmell now perceivable in the bit of putrid mutton, but that of the mixture.	Still fermenting; the liquor clear and ſweet; removed the bit of mutton and hung it up to dry, it being perfectly ſweet	Motion ſtopt; the bit of mutton dried and ſweet.	Diſtilled this mixture; an almoſt inſipid phlegm, with rather a vinous, than an acid taſte, was the produce.
(4) The ſame, with ſpinage.	In briſk fermentation; a heavy kind of ſweetiſh ſmell, not unlike that of the fenugreek ſeed.	Very briſk; ſuſpended a little bit of putrid mutton in the phial, ſo as not to touch the mixture.	Briſk; no ſmell in the bit of mutton, but that of the mixture.	Fermentation appeared to be almoſt over; liquor clear and ſweet; removed this and the phial with lemon-juice, to a cool place, and corked them cloſe; hung up the mutton.	Motion ſtopt, the bit of mutton dried and ſweet.	The ſmell of this mixture, before diſtillation, was a little inclinable to the cheeſy, and the phlegm obtained by diſtillation had a ſmall degree of pungency, with the ſame rancid flavour.
(5) The ſame, with water creſſes.	Motion not ſo briſk as in the two laſt, but conſiderably more ſo than in the ſimple mixture; ſmell of the herb but barely perceivable.	Very briſk; poured half an ounce of freſh ox-gall into the phial.	Not ſo briſk as in the morning; perfectly ſweet.	Liquor clear and ſweet; ſtopt the phial well, and removed it to a cool place; the mixture taſted a little of the gall.	Motion ſtopt.	This mixture was ſweet, with the fenugreek flavour.
(6) The ſame, with ſome *putrid* animal liquor.	Motion greater in this phial than in any of the others, with a thick ſcum and froth on the ſurface; not the leaſt ill ſmell to be perceived, tho' the putrid liquor was exceedingly offenſive when firſt added.	Very briſk; tho' in the coldeſt place of all the phials. (Every one of the mixtures were now perfectly ſweet, and had loſt the peculiar ſmell of the herbs, &c.)	Briſk and ſweet.	Still in briſk fermentation, and ſweet.	Removed the phial, and ſtopt it cloſe; fermentation now almoſt over.	The mixture was now upon the turn; a little ſourneſs juſt perceivable.

To face page 5.

which required a continual fire for three or four days.

IN order to have a ſynoptical view of the progreſs from time to time, I formed the annexed table, No. I. wherein I minuted down the ſeveral appearances, exactly as they ſhewed at each examination; but the general progreſs of the five mixtures that fermented was as follows:

IN three or four hours the inteſtine motion was evident; and ſoon after all the ſolid part of the mixtures roſe to the top; bubbles of air, and a thick ſcum, formed on the ſurface; a vapour, with ſome degree of pungency, and which extinguiſhed fire, now began to diſcharge itſelf, and the peculiar ſmell of the ſeveral ingredients having gradually gone off, a ſweetiſh kind of flavour, in ſome of the mixtures not unlike that of fenugreek ſeed, ſucceeded to it; while the motion becoming very briſk, little pieces of the ſolid matter every moment fell to the bottom of the phials.

THIS inteſtine motion continued for the periods expreſſed in the table; and by the time that it had ceaſed, the mixtures were clear, great ſhare of what formerly floated having now fallen down; they were alſo perfectly ſweet, and ſuch of them as were committed to diſtillation, ſent over a water, or phlegm, with a ſlight degree of pungency, and of the ſame ſweetiſh ſmell of the mixtures, excepting one, that had a little of the rancid, or cheeſy flavour.

THUS

Thus we see that the appearances, during the time that these mixtures were fermenting, are like those which attend the working of the sweet vegetable liquors; and, if fermented together in large quantities, such mixtures certainly would produce a liquor of an intoxicating quality.

For Travellers of good credit assure us, that there are among the great variety of *Tartar* tribes inhabiting the wilds of *Siberia*, some who have methods of obtaining an intoxicating liquor from milk, which is brought to ferment by the admixture of some putrid animal substance; which Dr. *Pringle* finds (and the same thing may be seen in the foregoing table, at No. 6) to encrease very powerfully the tendency to fermentation, either in milk, or in the common fermentative mixtures. And others of these northern nations, make themselves drunk with an extraordinary sort of liquor, (which, we may well imagine, is none of the most palatable) made by allowing fish and water to ferment in holes dug in the earth, and lined with the bark of the birch-tree.

Hence then it appears, that mixtures of animal and vegetable substances run regularly through the *three* stages of fermentation, termed by the chemists, the *vinous*, *acetous*, and *putrefactive*: but as the terms *vinous* and *acetous* can, with strict propriety, be applied to the fermentation of the sweet vegetable liquors only, it will be more clear and comprehensive, to denominate the *three* stages of fermentation,

tation, either ſimply, *firſt*, *ſecond*, and *third*; or, if it be more agreeable, *ſweet*, *ſour*, and *putrid*; and characteriſe them by their ſeveral products: The *firſt*, or *ſweet* ſtage, as yielding a ſweet,* agreeably pungent, *inebriating* liquor, which being diſtilled, gives over an *ardent ſpirit*. The *ſecond*, or *ſour* ſtage, as turning the ſubject manifeſtly ſour, and yielding an acid phlegm upon diſtillation. And the *third*, or *putrid*, when the texture of the ſubſtance fermented is fairly deſtroyed, and having loſt its original characters of taſte, colour, and ſmell, it becomes fetid, rotten, and offenſive; and, if committed to diſtillation, yields neither an inflammable ſpirit, nor an acid; but a ſharp pungent liquor, being a ſolution of volatile alcaline ſalt, nearly ſimilar to that ſalt which may be obtained, by the force of violent heat, from animal ſubſtances, without ſuffering them firſt to become putrid. †

The

* *Sweet*, as oppoſed to *ſour* and *putrid*. In the former edition, this matter concerning the drinks of the Tartar nations, was mentioned as a thing not yet ſufficiently proved, and therefore it was propoſed, to conſider the ſweet ſtage of fermentation as being two-fold; yielding, in the firſt inſtance, a ſweet, agreeably pungent, inebriating liquor, which, being diſtilled, gives Alcohol; and in the ſecond, a ſweet liquor which is not inebriating, and only a ſweetiſh phlegm on diſtillation: But, on inquiry, it is found, that the kinds of drink above-mentioned, really are in uſe among thoſe people; and that theſe liquors, when diſtilled, yield an Ardent Spirit: therefore, the diviſion propoſed is unneceſſary.

† When it is ſaid, that a volatile alcali may be obtained from putrid ſubſtances by diſtillation, it is to be remarked, that

THE reader, upon looking into the table, will find, that there were two little bits of putrid mutton put into two of the phials, while the mixtures were fermenting; and that these bits of flesh were rendered sweet. This was owing to the action of the vapour, set free during the fermentation; and, as will be shewn at large in another place, the vapour from the sweet vegetable liquors produceth the very same effect.

IT was found, that the vapour from the mixtures agreed likewise in another circumstance with the *Subtile Gas*, as it was termed by the old chemists, namely, that of extinguishing fire; and, I dare say, it would also suffocate animals. But notwithstanding that this vapour, if applied in large quantity to the lungs, might prove so very pernicious, yet it does not by any means follow, that it must necessarily produce the same deadly effect, if pent up in the bowels: we may be very certain that it does not; for if that were to be the case, people would be in very great danger after

that whoever makes the experiment, must not suffer such substances to remain too long before they are distilled, unless kept in close vessels; because the volatile alcali, which is the offspring of putrefaction, is dissipated as fast as it is generated, insomuch that, at length, nothing is left behind but an insipid water, or a solid matter, being an earth similar to common mould.

And it is in this way, that stinking water, after some time, becomes sweet; the volatile alcali, generated by the putrefaction of the animal and vegetable substances at first contained in the water, being, after a while, entirely dissipated, leaves the remainder without any disagreeable smell.

after almost every meal they eat. since it is evident, that the vegetables most commonly used as a part of our food, when mixed, either with flesh, or with the native animal juices, actually do raise a fermentation in the first passages, which must of course produce a great deal of this active vapour.

THERE is not sufficient ground therefore, for acquiescing in a theory which hath sometimes been taught, attributing the sudden death of people who had eaten largely of fruit, or the like, to the action of this subtile spirit, as supposing it to benumb and deprive the nerves of all power and influence.

IF this hypothesis were not ill founded, persons in these circumstances, who have been rescued from death by the timely exhibition of an emetic, would not recover themselves so immediately as they are known to do; which shews that the distress must have been occasioned merely by the over distension of the stomach; for had the pernicious vapour once fairly made its deadly impression, emptying the stomach would avail but little; and, if the party recovered at all, it would be but slowly, and not without much consequent relaxation, and weakness of the paralytick kind. *

THEREFORE, instead of imagining this active and subtile vapour to be productive of any harm in the body, it will appear hereafter, that there are very strong reasons for believing,

* Vide *Boerhaavii Elementa Chemiæ*, tom. ii. p. 180 181.

that it is the *grand preſerver* of animal fluids from *putrefaction*; that it attempers acrimony, is a *principal agent* in *nutrition*; and, perhaps, contributes ſomewhat to animal heat.

SINCE things of ſuch different natures as bread, lemon-juice, ſpinage, and water-creſſes, all run with equal facility into fermentation, we might almoſt venture to conclude that any vegetable, when mixed with an animal ſubſtance, and furniſhed with the requiſite quantity of water, will likewiſe ferment. But to try this matter ſtill farther, in a few days after going thro' the foregoing experiment, I mixed up no leſs than tweny-one of this kind of mixtures, moſt of them being in quantity about four ounces; *viz.*

1. Bread and water.
2. The ſame, with two drachms of ſaliva.
3. Bread and water, with green herbs.
4. The ſame, with two drachms of ſaliva.
5. Flour and water.
6. The ſame, with two drachms of ſaliva.
7. Green herbs and water.
8. The ſame, with two drachms of ſaliva.
9. Flour and water, with green herbs. (The green herbs were ſpinage, water-creſſes, and onions, equal parts, beat up together.)
10. The ſimple fermentative mixture. (*i. e.* Fleſh meat, bread, and water.)
11. Flour and fleſh meat, with water.
12. The ſimple mixture, with about an ounce of green water-creſſes.

13. Th

13. The ſimple mixture, with an ounce of ſpinage.

14. The ſimple mixture, with an ounce of green onions.

15. The ſimple mixture, ſix ounces; lemon-juice, one ounce.

16. The ſimple mixture, ſix ounces; freſh wort, one ounce.

17. The ſimple mixture, ſix ounces; ſtrong ſolution of ſugar, one ounce.

18. The ſimple mixture, ſix ounces; ſtrong ſolution of honey, one ounce.

19. The ſimple mixture, ſix ounces; vinegar one ounce.

20. The ſimple mixture, ſix ounces; brandy, one ounce.

21. A ſimple fermentative mixture, made with ſalt beef.

These mixtures were all made up at night, and lay fourteen hours before they were placed in a ſand bath, where it was intended to have kept up a moderate degree of heat.

They were all placed in the ſand at ten o'clock in the morning, being then, every one of them, perfectly ſweet——The fire was now ordered to be kindled: in ſix hours I went to ſee how things were going on, and was greatly vexed and diſappointed to find that the fire, through inattention of the ſervant entruſted with the care of it, had been made ſo ſtrong that the mixtures were all in a much fairer way to boil than to ferment. I therefore removed the phials from the ſand, and reckoned all this as ſo much loſt labour, not expecting,

after having been so much over-heated, that they would ferment at all. However, in six hours more, I again visited them, and finding some of the mixtures in motion, I marked down the several appearances, exactly opposite to each, as may be seen by looking into the second table, and first column.

BUT as I imagined that the natural course of the fermentation must have been disturbed from the first setting out, on account of the extraordinary heat, I was not very solicitous about a minute and accurate observation of the progress; more especially as I intended to take the trouble of mixing up an entirely new set. I therefore did not go near the place where the phials stood for two days, leaving them all this while in the cold; but going then to examine them, was surprized to find that notwithstanding their being unassisted by heat, yet most of them had fermented, and some of them were still in motion. I therefore minuted down, in the table, the appearances particularly belonging to each, as they stand in the second column.

SOON after this time, I engaged in a course of experiments, with a view of discovering the relative quantity of air, set free from different compounds, and therefore found it unnecessary to repeat all the experiments of the second table, as I had once intended; but at the end of a fortnight I went to the Elaboratory, where the phials had been left, and found some of them sour, some putrid, others musty, and

some

Table II. Of ALIMENTARY MIXTURES.

MIXTURES of	1.	2.
(1) Bread and water.	No ſigns of inteſtine motion.	Appears not to have ſtirred at all; ſour.
(2) The ſame, with about ʒij of ſaliva.	No ſigns of motion.	Appears to have fermented, there being froth at top; now at reſt, and quite ſweet.
(3) Bread and water, with ſome green herbs.	No ſigns of motion.	Had *not* ſtirred; ſmell of the herbs ſtrong.
(4) The ſame, with ʒij of ſaliva.	Motion fairly begun.	Had fermented; now at reſt; ſweet, of the fenugreek ſmell.
(5) Flour and water.	No ſigns of motion.	Had *not* ſtirred; not ſour.
(6) The ſame, with ʒij of ſaliva.	No ſigns of motion.	Had fermented; now at reſt; ſmell ſweet, like the fenugreek.
(7) Green herbs and water.	No ſigns of motion.	Had *not* ſtirred; ſmell of the herbs ſtrong.
(8) The ſame, with ʒij of ſaliva.	Motion beginning.	Had fermented; ſcum on the ſurface; ſmell ſweet, like the fenugreek.
(9) Boiled mutton, with ſome green herbs.	No ſigns of motion.	Had undergone the fermenting motion, tho' now at reſt, the mutton and herbs having all riſen to the ſurface.
(10) Bread and boiled mutton, with water.	Motion juſt perceivable.	Still in motion; great ſcum at top; ſmell ſweet, like the fenugreek.
(11) Flour and boiled mutton, with water.	Motion fairly begun.	Still at work; the ſmell perfectly ſweet.
(12) Bread and mutton, with water-creſſes.	Motion begun; ſmell of the herb not perceivable.	Had wrought briſkly; now on the decline; ſmell of the fenugreek ſtrong.
(13) The ſame, with ſpinage.	Motion begun; ſmell of the herb not perceivable.	Still at work; ſmell ſweet, exactly like the preceding.
(14) The ſame, with green onions.	Motion fairly begun; ſmell of the onion yet ſtrong.	Did not appear to have wrought much; ſmell of the onion ſtill ſtrong.
(15) The ſame, with juice of lemons.	No motion begun.	Had fermented; ſmell of the lemon entirely gone; mixture ſweet.
(16) The ſame, with freſh wort.	Motion fairly begun.	Not yet quite at reſt; ſweet; peculiar ſmell of the wort now loſt.
(17) The ſame, with ſugar and water.	Motion begun; not ſo briſk as the preceding.	At reſt; ſouriſh, with a little of the cheeſey ſmell.
(18) The ſame, with honey and water.	Motion begun, and as ſtrong as in the mixture with the wort.	Mixture ſweet, and at reſt; appears to have wrought pretty briſkly.
(19) The ſame, with vinegar.	No motion.	Does not appear to have ſtirred.
(20) The ſame, with brandy.	No motion.	Does not appear to have ſtirred.
(21) Salt beef and bread, with water.	No motion.	Appears to have wrought, the lighter parts, and much ſcum, being on the ſurface; ſweet, like the mixture with the freſh meat.

To face page 12.

ſome of the mixtures ſtill ſweet; but as I had not the table with me, did not minute them down particularly.

Now, ſince it appears, that theſe mixtures ferment ſo very readily, even when unaſſiſted by heat, how can there be any doubt but they muſt run through the ſame proceſs when they are received into the warm ſtomach, and are put in motion by the fermentative power of the ſaliva? which not only the authorities of *Hoffman* and *Boerhaave*, but likewiſe the experiments juſt now recited, ſhew to be poſſeſſed of this power in a very eminent degree; as may be plainly ſeen by comparing the numbers 1, 3, 5, and 7, of the ſecond table, with the mixtures numbered 2, 4, 6, and 8, in the ſame table.

ON this preſumption the progreſs of digeſtion in the human body may be traced in the following manner.

THE food, divided by *maſtication*, and mixed with the *ſaliva*, is fitted for beginning the *inteſtine motion* very ſoon after the alimentary ſubſtances are received into the ſtomach; this motion being raiſed by the temperate warmth of the place, perhaps by the remains of the former meal, but more certainly by the fermentative power of the *ſaliva*, and *gaſtric juice*. The firſt effect of this motion, is to throw up, to the ſurface, the ſolid part * of the alimentary mixture;

* Every perſon muſt have perceived, at one time or other, that after a hearty meal, if an eructation ſhould by any

ture; which soon again subsiding, the air that buoyed up the solid particles having escaped, the union of these is presently destroyed, and the whole mixed with the digestive fluids; this intimate mixture being much assisted and completed, by the agitation caused by the peristaltic motion, by the alternate pressure of the diaphragm and muscles of the abdomen, and by the continual pulsation of the neighbouring large blood vessels.

THUS the aliment passeth on from the *stomach* into the *duodenum*, and through the long tract of the *smaller intestines*; where having its original nature entirely changed, by the admixture of the *bile* and *pancreatic* juice, but *chiefly* by the fermenting motion, which still continues going on, the several kinds of food are all blended and mixed together into one mild, sweet, and whitish liquor, now in brisk fermentation, called *chyle*. This *chyle*, * so compounded,

any means be excited, some of the solid part of what had been taken into the stomach comes back towards the mouth. If the meal consisted of a mixture of animal and vegetable food, it is part of the vegetable that always rises; which corresponds exactly with the appearances in the phials, where I constantly observed the vegetable part of the mixture to rise first.

* That the chyle is a liquor in a state of actual fermentation may be proved by observing the changes that happen in milk, which is nothing but chyle, a very little animalized. "The acidity which milk naturally contracts in a few days, "must be considered as the effect of a fermenting motion "which discovers in that liquor an acid that was imper-"ceptible before; this, properly speaking, being an [illegible] "fermentation.

pounded, is taken up by millions of little abforbent veffels, fully charged with the fubtile active, antifeptic fpirit, and conveyed to the *receptacle*, where, and in the *thoracic duct*, it is further mixed with great quantites of *lymph*, and after no very long courfe, is poured into one of the large veins in order to comunicate its inteftine motion to the blood, to prevent the natural tendency of the fluids to putrefaction, and to repair the wafte which our bodies, every moment of our lives, muft neceffarily fuftain.

THE grofs, infoluble, and fecal parts of the aliment being thrown off from fuch as were finer and more nutritious, pafs on to the larger inteftines; where, at their very firft entrance, they meet with a ftore of four and putrid ferments, lodged in the *cæcum*, which, in a very fhort time, convert the alimentary remains into their own nature; and thus communicate a degree of fharpnefs which muft foon ftimulate the inteftines to a contraction, that ends in expelling thefe ufelefs and offenfive matters out of the body.

ALL this is to be underftood of the digeftive procefs, as carried on in perfons who have the happinefs

" fermentation, which the milk paffeth through in its way " to putrefaction, which foon follows if it be expofed to a " hot air." *Macquer*.

Hence the reafon why a diet confifting entirely of milk is fo apt to create a fournefs in the firft paffages; for being in actual fermentation when taken into the body, if it be not very foon carried through the fmaller inteftines, the fecond ftage will come on. And here we may perceive the neceffity that there is for the toffing and exercife of infants at the breaft.

happineſs to enjoy a perfectly ſound ſtate of health; but in valetudinary people, of weak and relaxed habits; in pregnant women, whoſe ſtomachs, and a great ſhare of the ſmaller inteſtines, are thruſt out of their natural ſituations; and in people whoſe inclinations or profeſſions oblige them to lead ſedentary lives: the food is often detained ſo long in the firſt paſſages, as to paſs on to the *ſecond* ſtage of alimentary fermentation: and then it produceth a moſt auſtere acid, which however is exactly in the ſame ſtate with a foreign acid, for the lacteals will admit none of it: It is therefore of neceſſity accumulated, and proves the cauſe of ſour eructations, heartburning, vomiting, griping, or looſeneſs, according to its quantity, degree of ſtrength, and place where lodged.

THIS ſour acrimony, when once eſtabliſhed, is not to be removed without ſome difficulty; for ſome of it always lying in the firſt paſſages, ſerves as a leaven to act on every thing taken into the ſtomach; and thus, hurrying the alimentary mixture through the firſt ſtage, and immediately bringing on the ſecond, renders the food incapable of furniſhing a nutritious chyle, as not being thoroughly changed and fermented, which plainly appears, from the paleneſs, and languid diſpoſition of thoſe people who are much afflicted with a ſourneſs in the ſtomach. And hence one reaſon, why exerciſe, eſpecially riding (which agitates the viſcera, and prevents the too long ſtay of the

alim[illegible]

aliment in the firſt paſſages) and the aromatic gums and bitters, together with chalybeates, (which produce the ſame effect, by their ſtimulating and ſtrengthening qualities) prove ſo very ſerviceable in all theſe caſes.

BUT if the aliment, either from its own very putreſcent nature, or from its too long ſtay within the confines of the ſmaller inteſtines, ſhould ever proceed on to the third ſtage of fermentation, it will then become ſo offenſive as to occaſion immediate efforts to throw it off, if the quantity of putrid matter be in any degree conſiderable; but if that ſhould not be the caſe, it may then remain in the body, and gradually inſinuate itſelf into the maſs of fluids, until it accumulates to ſuch a height as to throw the whole ſyſtem into a confuſion, which muſt terminate either in the concoction and expulſion of the offending matter, or in the deſtruction of life: For any thing putrid is totally incompatible with the perfect well being of an animal body; and therefore *Putrefaction* cannot by any means be admitted to a ſhare in the proceſs which is to furniſh this body with nouriſhment and ſupport.

THE ſpirit, or vapour, which is ſet free from the mixtures during their fermentation in the firſt paſſages, which enters the compoſition of the *chyle*, and with that fluid is tranſmitted to the *blood*, appears to be chiefly the *Fixed Air* of the alimentary ſubſtances; but as this matter cannot be fully explained, nor thoroughly un-

derftood, without a knowledge of the properties of *air*, when confidered as a conftituent principle of bodies, I muft referve the further illuftration until it be fhewn what thofe properties are.

ESSAY

ESSAY II.

ON THE NATURE and PROPERTIES OF FIXED AIR.

May we not, with good reason, adopt this now fixed, now volatile Proteus, among the chemical principles, and that a very active one?

HALES.

THAT great improver of natural knowledge, the honourable Mr. *Boyle*, knew from a variety of experiments, "that air might be produced by the fermentation, corrosion, and dissolution of bodies; by the boiling of water, and other liquors; by the mutual actions of bodies upon one another, especially the saline ones; and, lastly, by the analysing and resolving certain substances;"* but this noble philosopher seems not to have

 known

* Boyle's Works, abridged by Shaw, vol. iii. p. 21.

known the principal uſe of this air, which is ſo intimately mixed with, and wrought into the compoſition of animal, vegetable, and mineral bodies.

IT is therefore to the indefatigable induſtry of the excellent Dr. *Hales*, that the world is indebted for the diſcovery that this elaſtic matter, ſo nearly reſembling common air, is the *principle* which *forms* the *cement*, or *bond of union*, between the ſeveral conſtituent particles.

BUT although it is now near forty years ſince this truly uſeful philoſopher publiſhed the account of his curious experiments, and thereby opened a new field in natural philoſophy, yet the enquiry hath been but little proſecuted; and, excepting the Baron de *Haller*, there is no ſyſtematic writer that I know of, either in chemiſtry or phyſiology, who has given that attention to Dr. *Hales*'s diſcoveries which they certainly merit.

THIS celebrated phyſiologiſt indeed hath fully adopted the ſyſtem of *Hales*, and holds *air* to be the *vinculum elementorum primarium*, the *true cement* which binds together the earthy particles of bodies.*

ALL

* Videtur aer vinculum elementorum primarium conſtituere, cum non prius ea elementa a ſe invicem diſcedant quam aer expulſus fuerit. *Halleri Elem. Phyſiologiæ*, tom. i. in capite primo.

Aeris dotes (*in ſanguine ſcil.*) nondum ſatis notæ ſunt.— Id interim certum eſt, ad Gluten pertinere, quo omnium firmorum in univerſa Natura Corporum elementa cohære-

ut

ALL the other writers ſeem either not to know, or not to believe any thing of this theory; ſince ſome of them make *Phlogiſton* the bond of union, others look on *water* as the *cementing principle*, and ſome aſcribe coheſion ſolely to the attraction ſubſiſting between the particles of elementary *earth*.

AND it is this laſt opinion which is embraced by the learned *Gaubius*;* but it did not occur to this very celebrated profeſſor, that if *earth* were the *only* cauſe of *coheſion* in bodies, there *never* could be any *change* in their *combination*: For "if all the parts of matter were "only endued with a ſtrongly attracting power, "whole nature would then immediately become one unactive, cohering lump; wherefore it was abſolutely neceſſary, in order to "the actuating and enlivening this vaſt maſs "of attracting matter, that there ſhould be "every where intermixed with it a due proportion of ſtrongly repelling elaſtic particles, "which might enliven the whole maſs by the "inceſſant

ut omnino, neque fere metallum, neque os, neque lapis, neque teſta, neque Sal diſſolvatur quin aer extricatus prodeat. *Ejuſdem*, tom. ii. p. 155.

* In ſicca materie terreum præ aliis cohærentiſſimum eſt, atomorum ſuarum in proximos contactus compactione duritiem daturum vix edomandam niſi aliorum interventu molliretur. Hoc principium cohæſionis, quietis inertiæ. Et ipſa glutina, terræ quam continent ſuam cohærentiam debent. *Gaubii Inſtit. Patholog. Med.* ſect. 142 & 143.

But iſinglaſs, and other ſubſtances of the like nature, are deprived of the glutinous quality by quick-lime; the reaſon of which will be laid before the reader in the courſe of theſe Eſſays, particularly the fifth.

"incessant action between them and the at-
"tracting particles."*

Now the distinguishing property of the earthy-principle is, that it resists the action of fire, and remains behind the rest, after they are all raised or dissipated: But it is plain, that the principle upon which cohesion *immediately* depends is of a *volatile* or *fugitive* nature, not *fixed* and *inert*, like earth; otherwise, the face of this globe would be covered with *dead* bodies; for when once a stop is put to the life of either animal or vegetable, they become no longer useful in the general system, as organized bodies; and it is then absolutely necessary that their frame should be dissolved, and their elementary particles dispersed, in order to form nourishment for those beings that yet continue to live.

IT will appear hereafter, that the opinions of *Hales* and *Haller* are well grounded; and that the *principle* which is generally known by the name of *Fixed Air*, is the *immediate* cause of cohesion, since the preservation of firmness and soundness in bodies depends on restraining the escape of this *air*; for the moment it *flies off*, and *resumes its elasticity*, we shall see that the other constituent particles, the *earthy*, the *saline*, the *oily* or *inflammable*, and the *aqueous*, being thereby put in motion, immediately begin to exert their several peculiar attractive and repulsive powers, and run into *new combinations*, which first change, and at length alto-
gether

* Hales's Staticks, vol. i. p. 314.

gether destroy, the texture of the substance they formerly composed, provided that this substance contained in itself a sufficient quantity of water to allow of the intestine motion, by giving the proper degree of fluidity;* for without fluidity there can be no intestine motion, and without intestine motion there can be no change of combination; since we see that such animal and vegetable bodies as are suddenly deprived of their water, or naturally contain very little, are almost as durable and unchangeable in their textures as minerals.

THAT this *air*, which is alledged to be the *cementing principle*, should have the property of passing, from a *repellent elastic* state, to the opposite, of *nonelastic* and *strongly attracting*, and *vice versa*, is not easily comprehended; nor indeed could it be believed, if the number of experiments, which prove it, had not put the matter beyond all manner of doubt: So that the fact is as certain as that we breathe air. †

THIS, as well as the property of *elective attraction* in the minute particles of matter, was not unknown to that amazingly-comprehensive genius, Sir *Isaac Newton*; ‡ and it was by pursuing the hint of that great man, that Dr. *Hales* engaged in an enquiry which enabled him

* Here we are not to understand absolute fluidity, but only such a degree of moisture and softness as will allow the several constituent particles to shift and change their places.

† See Hales's Staticks, vol i. p. 293, and vol. ii. p. 279 & 281.

‡ See Newton's Optics, quest. 30 & 31.

him to eftablifh the theory aforementioned, and which hath been illuftrated and confirmed, with regard to a particular clafs of bodies, by the experiments of Dr. *Black*. *

BUT there is ftill a great deal wanting to complete the illuftration, which demands a number of accurate experiments; more, perhaps, than will fuit the leifure or inclinations of any one perfon, and therefore muft be brought to perfection by the united labours of many.

WITH this view, I began a fet of experiments, and refolved to obferve carefully the appearances attending the fermentation of fuch mixtures as ufually make up part of our food, and alfo the appearances which attend the putrefaction of animal fubftances; hoping from this branch of enquiry to obtain further light concerning fome points of very great importance in the animal œconomy.

EXPERIMENT I.

To try the relative quantity of air, fet free from different mixtures by fermentation, I put into three phials, marked 1, 2, and 3, firft, the fimple fermentative mixture, about three ounces; fecondly, a like quantity of bread and water; and the third phial had nothing but three ounces of common water; thefe two laft being defigned as ftandards.

THE

* In his experiments on *Magnefia*.

THE phials, as represented at B (fig. 1.) were placed in a tin pan (A) half full of water, on little pedestals, and covered over with cylindrical glasses (C) of seven inches in height, and three in diameter.

THE air was then drawn out of the cylindrical glasses, by suction through a syphon, so as to raise up the water about half way, and then little bits of paper were pasted on the sides, to mark the rise of the water.

EVERY thing being thus ordered, the whole apparatus was placed before a fire, at such a distance as was sufficient to keep up a moderate degree of heat.

As the heat began to operate, the vapour in each of the glasses expanded itself, and forced down the water to a certain depth, nearly about half an inch; but at the end of eight hours, when the mixture of bread and flesh-meat (No. 1) was in brisk fermentation, the water in its cover was sunk one-third more than in the other two, and in twelve hours it was double, being then a complete inch from the mark.

DURING the night, the whole became cool; the consequence of which was, that the expanded vapour in the glasses 2 and 3 was found in the morning perfectly condensed, the water having returned to its original heighth; while the air that had been set free from the fermenting mixture (No. 1) still maintained its elasticity, keeping down the water in the cylindrical glass an inch and two-tenths.

THE pan was again placed before the fire; and, at six in the evening, the water in the glass belonging to No. 1. was forced down two inches, that in the other two half an inch.

NEXT morning, the vapour being again condensed by the cold during the night, the water stood at an inch and a half from the mark in the fermenting phial, but in the phials No. 2 and 3, it rose to the marks as before.

I placed the whole again near the fire, and the vapour operated as before. On the third morning, the water belonging to the phial No. 2 had returned as usual to the original heighth; while in the other, No. 1, it was still kept down a full inch and half, by the force of the extricated air.

I now threw out the bread and water (from No. 2) and put into the same phial half an ounce of boiled beef cut small, and two ounces of water; and having placed it under the cover, and raised the water by suction, as before, I set it in the pan along with the fermented mixture, which by this time had entirely ceased from working. After standing six hours in the warmth, no elastic air appeared to have been set free from the beef, the water being sunk only half an inch. The other phial (No. 1) now stood exactly at an inch and a half, which, allowing half an inch for the expansion of the vapour, shewed that the mixture had now been for some time in a condition to absorb air, as Dr. *Hales* termed it, for

at

at the ſame hour on the day before the water was down two inches.

ON the 4th morning, when all was cool, the fermented mixture was found ſtill to keep down the water near an inch, but in the glaſs with the beef only the water was up to the mark.

FROM hence, and from other experiments,* it ſhould ſeem, that animal ſubſtances when alone, and the ſubſtance of vegetables when alone, do not part with their air without ſome reluctance; but that when the two are mixed together, under certain conditions, that then an attraction begins, which preſently throws off the air that ſo cloſely adhered to each of them in a ſeparate ſtate; and this air, in the moment of its extrication, reſuming its elaſticity, deſtroys the union of the minute particles, and, producing, an inteſtine motion, totally changes the nature of the body in which it was fixed, by allowing a new diſpoſition, and a different combination, to take place.

IT has appeared that the alimentary mixtures, though at firſt they throw off a conſiderable quantity of elaſtic air, yet, after ſome time, they *abſorb* this air, and again reduce it to a *non-elaſtic* ſtate.

As the fermentation in the ſtomach muſt begin very ſoon after the aliment is received into it,

* See No. 1 of the firſt table; and No. 1, 3, 5, and 7, of the ſecond table; and compare them with thoſe mixtures that had either fleſh or ſaliva.

it, we may reaſonably concludc, that the alimentary mixture will alſo begin to *abſorb* much ſooner in the bowels than it appeared to do in the phial; and thus the elaſtic air, which is ſet free from the food, will, in great meaſure, return to a fixed, or non-elaſtic ſtate, before the chyle enters the lacteals. *

IT has been imagined by a very ingenious gentleman, † that the alimentary ſubſtances carry their fixed air into the blood, without its ever having been extricated, or thrown off into an elaſtic ſtate, during digeſtion; but this is to ſuppoſe, that theſe ſubſtances are never thoroughly broken, nor ſuffer any change of combination, from the action of the digeſtive organs; a ſuppoſition which cannot

* "Since we find ſuch great quantities of elaſtic air generated in the ſolution of animal and vegetable ſubſtances, it muſt needs be, that a good deal does conſtantly ariſe from the diſſolving of the aliments in the ſtomach and bowels, which diſſolution it greatly promotes; ſome of which may, very probably, be reſorbed again by the fumes which ariſe with them.——Thus we ſee, that the variety of mixtures in the ſtomach appear ſometimes to generate, and ſometimes to abſorb air. In a true kindly digeſtion, the generating power exceeds the abſorbing power but a little; but whenever the digeſtion deviates in ſome degree from this natural ſtate, to generate a greater proportion of elaſtic air, then are we troubled more or leſs with diſtending flatuſes." *Hales's Stat.* vol. i. p. 309.

† Dr. *Black.* In his *Diſſertatio Med. Inaug. De Humore acido a Cibis orto,* he is ſo far from believing that the aliment naturally ferments in the ſtomach, that he looks on ſuch fermentation, when it does happen, to be the cauſe of many, and thoſe very dangerous diſeaſes. See p. 8, and 9 of the *Theſis* above-mentioned.

cannot by any means be allowed; it being *demonſtrable* (as I humbly apprehend) that the food is intirely broken, and its original nature totally changed while it is paſſing through the alimentary canal.

EXPERIMENT 2.

INTO the ſame three phials which were made uſe of in the foregoing experiment I put, firſt, the ſimple fermentative mixture; 2, the ſame, with one-third freſh lemon-juice; 3, the ſame, with one-third claret.

THE phials were all placed in the pan as before, and the water drawn out by ſuction. The phial, No. 1, preſently began the motion, the ſolid part all riſing to the top; and as it fermented, I found that more air was extricated than their had been from No. 1, of the preceding experiment, which I aſcribed to the tenderneſs of the mutton which was uſed in this preſent mixture, as having been longer kept than ſome beef that I had mixed up for the former trial.

No. 3, with the claret, did not begin to move until it had ſtood 24 hours; and No. 2, with the lemon-juice, after remaining thirty-ſix hours, ſhewed no ſigns of motion at all; ſo that here the proportion of lemon-juice was too great; and it appears to have acted as a pure acid, which, as well as fermented liquors, is found to reſtrain the alimentary fermentation.

EXPE-

EXPERIMENT 3

AT the end of thirty-ſix hours, I threw out theſe mixtures, and filled the phials again, with, 1, the ſimple fermentative mixture, and an ounce of green herbs; (*viz.* onions, water-creſſes, and garden-creſſes, *aa p. æ.*) 2. The fermentative mixture, with an ounce of lemon-juice and half an ounce of *ſaliva*; 3. The mixture, with two drachms of very ſtrong rum.

THE mixture, No. 2, with the lemon-juice and *ſaliva*, began to ferment immediately; and, before two hours were expired, all the ſolid ingredients had riſen; No. 1 began ſoon after; but it was not till after ten hours, that the mixture with the rum ſhewed any ſigns of motion.

HERE we have another ſtrong inſtance of the fermentative power of the *ſaliva*, which being compared with thoſe in the ſecond table, plainly ſhew that *Boerhaave* and *Hoffman* were both in the right, when they aſcribed this quality to that fluid.

WHEN the mixture with the lemon-juice had ceaſed from working, I dropt *Lixivium Tartari* into ſome of the liquor, but not the leaſt ebullition enſued, which ſhews, how intirely the fermenting motion changes the nature of the ſubſtance fermented; for here was one-third of this mixture, a ſharp acid liquor, which would have efferverſced violently

lently before the fermentation began; and hence we may conclude, that acids, even independant of their mixture and dilution by the native animal juices, muſt be neutralized by the mere force of fermentation in the firſt paſſages, if the digeſtion proceeds as it ought to do.

IN the mixture with the herbs, the ſmell of the onion was ſtill very ſtrong, even after the fermentation was over; which agrees with what every body muſt have perceived, with regard to the fermentation of things of this ſort in the ſtomach; ſome of this tribe, ſuch as garlick, retain their peculiar ſmell, even after they have undergone ſo much of the action of the body, as to become perſpirable matter.

ALTHOUGH the mixture with the rum was the lateſt in beginning, yet, after the motion began, it was more briſk, and finiſhed its career ſooner, than either of the other two phials; but not above half the quantity of air was extricated that their was from the ſimple mixture, No. 1, of the foregoing experiment.

EXPERIMENT 4.

TWO of the phials were placed in the pan and covered with the glaſſes; one having two ounces of a caudle, made of oaten gruel, Liſbon white-wine, and ſugar, with a little lemon-juice; and the other, the ſame quantity of the caudle, and two drachms of *ſaliva*.

THE

THE phial which had the *ſaliva*, began the fermenting motion immediately, but it never became briſk, and in about 14 hours intirely ceaſed; a ſmall quantity of air was extricated at firſt, but the mixture ſoon went on to the abſorbent ſtate, for by the time that the fermentation had ceaſed, the water in the cylindrical glaſs was raiſed half an inch *above* the mark.

THE other phial without the *ſaliva* never ſhewed any ſigns of motion.

EXPERIMENT 5.

I filled the three phials, 1, with juice of turnips alone; 2, the ſame juice, with two drachms of *ſaliva*; and, 3, bread and water, with two drachms of ſaliva, and as much ſpirit of vitriol as gave the mixture a conſiderable degree of ſharpneſs, and made it effervеſce ſmartly upon dropping in *oil of tartar*.

THE phial No. 2, with the *ſaliva*, began to ſhew ſigns of motion immediately; and, in five or ſix hours, the ſimple turnip juice was likewiſe in motion, and both the one and the other fermented very briſkly.

BUT No. 3, though it ſhewed ſigns of motion very early, never became briſk; ſo much had the acid deſtroyed the fermentative power of the *ſaliva*. However, what little motion it did undergo, ſo far altered the ſtate of the acid, that it would not effervеſce, upon adding the fixed alkali.

EXPERIMENT 6.

INTO one of the phials I put three ounces of the simple fermentative mixture, and a drachm of the *cortex* in powder; into the second phial I put the same quantity of the mixture, and a drachm of *carraway-seeds* in powder; the third had nothing but three ounces of the mixture, to serve as a standard to the other two.

THE phial with the *bark* began to shew signs of motion as soon as it became warm, and the other, with the seeds, in two hours after; the simple mixture was not in motion till three hours later.

THE *cortex* fermented very briskly, as did also the carraway-seeds; but there was at least one half more air extricated from the latter than from the former, which shews that many of the carminatives may generate air in the bowels, as well as expel it: And if these things were given in large doses, we might account for their action, by saying, that it is the sudden extrication of their air which stimulates the muscular coat of the stomach, and enables it to throw off the offending flatus.

BUT as they are always given, and indeed can only be taken in small quantities, it is upon the hot oil with which these aromatic substances abound, that their carminative virtue depends; for we see that ardent spirits, which

neither contain much air themselves,* nor facilitate the extrication thereof from any thing they are mixed with, are yet very powerful carminatives, which must therefore be owing solely to their power as stimulants.

EXPERIMENT 7.

I HAD, on a former occasion, made up mixtures with sugar, wort, and honey, but as the progress of that experiment was interrupted, I resolved to repeat it.

THREE mixtures were made accordingly:

1. Of boiled mutton (without any bread) ℥ss, water ℥ij, and fresh wort, or infusion of malt, ℥ij.

2. The same quantity of mutton and water, with two ounces of a strong solution of brown sugar (about four to one).

3. The like quantity of mutton and water, with two ounces of strong solution of honey.

THESE phials were not placed in the pan, as in the foregoing experiments, but stood in a sand bath, heated by a lamp.

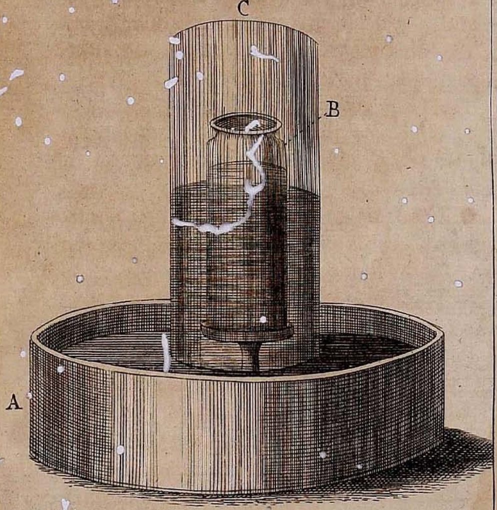
THE mixture, No. 1, with the wort, was the first that began the fermenting motion, and that very early, in less than an hour after the phial became warm; the sugar began next, about two hours later; but the honey was not in motion until it had stood above eight hours.

* "I found very little air in 54 cubick inches of brandy." *Hales's Stat.* vol. i. p. 181.

I FRE-

facing P. 34

Fig. 1.



I FREQUENTLY ſhook all theſe mixtures, and found the fermentation greatly accelerated thereby.

TRUE it appears that honey is not ſo fermentable, when mixed with animal ſubſtances, as ſugar; nor ſugar ſo prone to fermentation as the common infuſion of malt; and perhaps thoſe diſturbances in the bowels, which are often obſerved in people of delicate and very irritable conſtitutions, after the uſe of honey, are occaſioned by this refractory quality, ſince it may lie a conſiderable time undiſſolved in the ſtomach, and there act as a ſtimulating ſalt.

UPON the ſame principle, this may guide us in directing ſugar and honey in the diet of ſick perſons: Where the nature of a diſeaſe requires a diet of the moſt eaſily fermentable kind, ſugar muſt be preferable to honey; unleſs ſomewhat of a laxative nature be likewiſe demanded, when honey, unleſs the patient has a peculiar diſlike to it, will have the advantage.

EXPERIMENT 8.

WHILE theſe mixtures were in fermentation, I ſuſpended a little thin bit of very putrid mutton in the neck of the phial with the wort, and left it there during the night; in the morning it was found to have loſt the putrid ſtench, having now no ſmell but that of the mixture.

EXPERIMENT 9.

I ALSO fixed one extremity of a bended glaſs tube into the neck of the phial with the ſugar, and the other into a little bottle containing a drachm, or thereabouts, of the ſpirit of *ſal ammoniac* made with *quick-lime* (as repreſented in the third figure). After they had remained in this ſituation twenty-four hours, I ſeparated the phials, and dropping in ſpirit of vitriol on the volatile alkali, found it effer-veſce very ſmartly.

AFTERWARDS, I transferred the air from a ſimple fermenting mixture (*i. e.* Bread, fleſh meat, and water) into the ſame cauſtic volatile alkali; as I did likewiſe from melaſſes waſh * in fermentation, and from a mixture of *cortex* and putrid bile, which fermented briſkly, and ſweetened the putrid gall, all with equal ſucceſs; in every one of theſe inſtances the ſpirit of *ſal ammoniac* effervеſcing very ſmartly, after having been ſupplied with air from the ſubſtances in fermentation.

WHICH ſhews, that the air ſet free during the fermentatory proceſs, although it reſumes its elaſticity immediately on being thrown off, is yet capable of returning inſtantly to a fixed ſtate

* Melaſſes waſh, as it is termed by the diſtillers, is a liquor brewed from melaſſes and water, and afterwards fermented by the means of yeaſt; in order to diſtil, and make what are uſually called ſugar-houſe ſpirits.

ſtate, provided it meets with any ſubſtance which hath the power to receive it.

BUT here I find that I have been proceeding rather too faſt, unleſs the reader ſhould happen to be perfectly well acquainted with Dr. Black's very ingenious paper on the *magneſia*: if he is, I ſhall be underſtood; if not, I ſhall appear to have talked in a language altogether unintelligible.

IT is ſufficiently known, that the *volatile alcaline ſpirits*, when made by the admixture of *quick-lime* in the diſtillation (which they for the moſt part are, in order to render them more pungent) *do not effervеſce* upon the addition of an acid; and that no ſalt, in a concrete form, ever riſes when the proceſs is carried on in this manner.

BUT it was never well underſtood what occaſioned theſe peculiarities, until Dr. *Black* publiſhed his experiments.

FROM theſe it appears very plainly, that *calcareous earths* have a ſtrong degree of *affinity* with *fixed air*, and in their natural ſtate abound with it; that by *calcination* they are *deprived* of their *air*, and on account of this deprivation, acquire a high degree of *cauſticity*, and become *ſoluble* in water; and that, on the other hand, this cauſticity is deſtroyed, and the quick-limb rendered *mild*, and *inſoluble*, by *reſtoring* its *fixed air*.

Now crude *ſal ammoniac* is a combination of the *marine acid* with the *volatile alcali*; but it naturally contains no *fixed* air. *Quick-lime*, therefore,

therefore, when joined with *ſal ammoniac*, in order to make the volatile ſpirit, detains the acid of the crude ſalt, and ſuffers nothing but the volatile alcali to riſe along with the phlegm in the diſtillation: But this ſpirit, ſo raiſed, having *no fixed air* in its compoſition, cannot effervеſce upon the addition of an acid; for effervеſcence depends on the fixed air of the mixture flying off, and reſuming its elaſticity, while the acid and alcaline particles are ruſhing into cloſe union; * neither can the particles of the volatile ſalt run together, and form chryſtals, becauſe *air* is the *bond of union* in this ſalt. But when *chalk* or *fixed alcaline ſalts* are uſed in the diſtillation, theſe ſubſtances, being replete with *fixed air*, ſend over ſome of it along with the volatile alcali; and this air, renders the ſpirit mild and effervеſcent, and enables the ſalt to put on the concrete form.

NEUMAN imagined, that "perhaps the "quick-lime abſorbs, and detains the earthy "matter, which is the baſis of the volatile "ſalt, and on which its ſolid form and its ef-"fervеſcence with acids depend." And he relates, "that on keeping ſpirit of ſal ammo-"niac, made with quick-lime, for ten years, "it loſt almoſt all its volatility and ſubtility, "and in this ſtate effervеſced ſtrongly." †

BUT

* Vide *Boerhaav. Element. Chemiæ*, tom. i. p. 531, & tom. ii. p. 398.

† *Neuman's Chemiſtry by Lewis*, p. 223.—*Du Hamel's* theory is, that when ſal ammoniac is diſtilled with chalk, or

BUT there is not the leaſt occaſion for waiting ſo long to produce this change in the nature of the *cauſtic volatile alcali*, ſince it may at any time be brought about in ten minutes by transferring the air from ſome other ſubſtance into the *non-effervesſcent* ſpirit; as any one may eaſily ſatisfy himſelf by the following exceedingly pretty and concluſive experiment, which is the contrivance of Dr. *Black*, and communicated by him to my very ingenious friend Dr. *Francis Hutcheſon*, lecturer of chemiſtry, in the univerſity of *Dublin*.

PUT a ſmall quantity of the volatile ſpirit made with quick-lime into the little phial marked A, in figure 2, and fix cloſely into its neck, ſo as that no air may eſcape, one leg of the bended glaſs tube (B) and inſert the other, and likewiſe lute it well, into the mouth of a larger phial (C) into which ſome alcaline ſalt hath been previouſly put. This phial muſt have a little hole drilled in the upper part of it,

or fixed alcaline ſalts, ſome portion of earthy matter comes over with the volatile alcali, and enables it to form a concrete ſalt; whereas, when quick-lime is uſed, no earthy matter riſes in the diſtillation; tho' it does not appear why the earthy matter ſhould not riſe as readily from quick-lime, as from chalk or fixed alcali. He likewiſe adds, that as lime has the property of detaining groſs oily matter, it keeps down the groſs part of the volatile alcali, which is of an oily nature, and lets only the more ſubtile part come over with the phlegm in the diſtillation; and hence the ſpirit made with quick-lime becomes ſo much more pungent and volatile.

See the 2d & 3d memoir on ſal ammoniac in *Mem. de l'Acad. Royale des Sciences*, for the year 1735.

it, as at D, that through this aperture, and by means of the small glass funnel (E) an acid may be gradually dropt in.

THINGS being thus fixed, pour in spirit of vitriol, or any other acid, that an effervescence may ensue; and while that is going on, the little hole (at D) is to be stopt occasionally, in order to force over the extricated air into the phial A. An ounce of alcaline salt expended in this manner will serve to supply a like quantity of *caustic* alcaline spirit with a sufficiency of air to make it effervesce very smartly, when the phials are separated, and an acid dropt into the one which contains the (before) *non-effervescent spirit*.

EXPERIMENT 10.

MANY of the preceding experiments have shewn, in the strongest light, the fermentative power of the *saliva*: I determined, however, to try it once more, and to compare it with the *bile*, in regard to this quality.

I THEREFORE mixed an ounce and half of bread and water, beat up thin, with half an ounce of *saliva*: and the same quantity of bread and water, with half an ounce of *ox-gall*.

THE first mixture shewed signs of motion from the very beginning, and, in less than an hour after it became warm, the motion was brisk; the second, with the gall, was not so soon in motion, it being three hours before the bread had all fairly risen to the surface; but the

the fermentation continued twice as long, and the motion was more brisk than in the mixture with the *saliva*.

AND thus it appears very plain that the *bile* has a power, like other animal fluids, to raise fermentation, when mixed with vegetable substances.

EXPERIMENT 11.

Two drachms of boiled mutton, perfectly sweet, were beat up with an ounce of water, and put into one phial; the same quantity of the mutton beat up with half an ounce of *saliva*, and as much water, were put into another phial; and both of them left in the common temperature of the air, which was cool for the season (beginning of June) the thermometer being at 60.

IN thirty-six hours, the contents of the first phial became putrid; the other, which had the *saliva*, remained sweet for forty-eight hours; but both of them fermented; that is to say, an intestine motion took place, the solid part all rose to the surface, and bubbles of air repeatedly formed, and continued discharging themselves, for several hours before any putrid smell was perceivable.

EXPERIMENT 12.

A DRACHM of boiled mutton, perfectly sweet, beat up with an ounce of water, was

put into one phial; the same mixture was put into another, and a bit of thread being dipt in some putrid liquor which lay about rotten beef, about the tenth part of an inch of this thread was cut off, and thrown into the phial.

IN twenty-four hours, the contents of the second phial, after undergoing the intestine motion, were found putrid; the first did not betray the least putrid smell until it had stood twelve hours longer.

I REPEATED this with *bile*, and found the phial into which I had put the bit of putrid thread began to smell several hours sooner than the other, which contained *bile* and water only.

THESE experiments confirm the eighteenth of Dr. *Pringle*'s, and plainly shew, that bodies in a state of putrefaction are *exciting ferments* to such as are sweet.

EXPERIMENT 13.

IT has appeared from the 6th of these experiments, that the *cortex* ferments very readily when joined with a mixture of animal and vegetable matters, and even seems to promote that fermentation; but I was desirous to know how it would operate when joined only to the *saliva*.

WITH this view, I mixed up a drachm of the *bark* in powder with half an ounce of *saliva*, and as much water. At first, there did appear some signs of motion, but they pre-

fently

ſently went off, and at the end of eighteen hours I found the mixture perfectly at reſt, notwithſtanding it had ſtood the firſt ſix hours of this time in a moderate degree of heat; for the laſt twelve, indeed, it had been ſuffered to cool.

I now added half an ounce of *ox-gall*; but no motion enſued till twenty hours more were elapſed: Then I found the ſolid part getting up to the ſurface, and the air-bubbles collecting and diſcharging; but it is to be obſerved that the phial, all this while, remained in the cold.

Finding the motion begun, I placed the mixture in a moderate degree of heat, and then the fermentation became extremely briſk, and continued for twenty-four hours, throwing off great quantities of air; after which it ceaſed, owing, as I conjectured, to the frequent agitation of the phial, which, as hath been before obſerved, conſiderably haſtens and ſhortens the periods of this kind of fermentation.

EXPERIMENT 14.

In order to cloſe this ſeries of experiments, I thought it would not be improper to try the ſeveral common *farinacea*, and to compare them with each other, in regard to their reſpective fermentative qualities; as this might be of uſe in determining which of them are eaſieſt of digeſtion.

HAVING made up four mixtures of wheat, barley, oats, and rice, all previously freed from their outward shells or husks, and well boiled, so as to burst the grain, and beat up with the usual proportion of water and flesh meat, * they were then severally put into phials, and placed in a moderate degree of heat, about twelve hours after they were first mixed.

IT was not easy to say whether the rice or the barley began first, for both of them were in brisk motion by the time that they had stood an hour in the warmth; the mixture with the oats was not in motion till about four hours after it became warm, and the one with the wheat was three or four hours later than it.

THEY all fermented very briskly, and being often agitated, ran through their first stage in about forty-eight hours.

THUS we may infer, that crude barley † and rice will prove light and easily digestible food; oats next to them; and wheat the most stubborn and indigestible of all. But at the same time we see, that this property in wheat renders it by much the fittest of all the *farinacea* for the making of bread; as it appears to have firmness sufficient to enable it to bear some degree of fermentation in the baking, and yet retain enough of its substance to undergo the alimentary fermentation afterwards in the body.

* Boiled veal was used in this experiment.

† The barley here used was what is commonly termed pearl-barley.

BY this time I had ſufficiently ſatisfied myſelf with reſpect to the manner in which digeſtion is carried on in the human body; being now fully convinced that it is neither more nor leſs than a true fermentatory proceſs: For if we conſider the end of digeſtion, which is thoroughly to change, ſeparate, and reſolve into their conſtituent particles, the different ſubſtances on which we feed; and ſince we ſee that all mixtures of animal and vegetable ſubſtances, if furniſhed with the requiſite quantity of water, and kept in the proper degree of heat,* naturally and ſpontaneouſly run into fermentation, without the aſſiſtance of any *exciting* ferment, how is it poſſible to think otherwiſe, than that the ſame kind of mixtures muſt ferment in the body, when at their very firſt entrance they meet with a fluid, which, even if their own natures were averſe from fermentation, would immediately bring it on? And as they paſs farther on, into the *ſtomach* and *duodenum*, they ſtill meet with more fluids, endued with the ſame power, in an equal, or perhaps ſuperior degree: Can it be imagined then, that theſe ſubſtances, when ſo circumſtanced, will not undergo the changes natural to them? and that a fermenting motion will not inſtantly commence, and continue ſo long as they remain in a place where they are free to act, uninfluenced by any more powerful ferment; that is to ſay, ſo

* Even heat, we find, is not always neceſſary; ſo prone are many of this ſort of mixtures to ferment.

ſo long as they remain within the confines of the *ſmaller inteſtines*? But ſoon after the *valve* of the *colon* is paſſed, and that the alimentary mixture, which as yet is only in its *firſt* ſtage, comes into contact with the *acido-putrefactive* contents of the larger inteſtines, then is its ſweetneſs deſtroyed, and it proceeds on to the *ſecond* and *third* ſtages, and thereby acquires a degree of ſharpneſs and corruption,* which is now become as neceſſary as it was that the ſweetneſs ſhould continue while the food remained in the firſt paſſages.

EXPERIMENT 15.

A DRACHM of ſalt of wormwood being put into one of the cylindrical glaſſes deſcribed in page 34, and which was uſed to cover the phials, and an ounce, or thereabouts, of juice of lemons, being poured on the ſalt, the mouth of the glaſs was ſtopt, while the ebullition continued, in order to confine the air which was extricated from the mixture.

WHEN the effervefence ceaſed, a *live ſparrow* was thrown into the glaſs, and in leſs than half a minute expired.

THUS we ſee that the air which is extricated from bodies by effervefcence, as well as that which is ſet free in the firſt ſtage of fermentation, and conſtitutes the *gas ſylveſtre*, hath

* It is to be obſerved, however, that the putrefaction of the *fæces alvinæ* is of a peculiar kind; and is never, excepting in ſome morbid caſes, ſo complete as to furniſh a *volatile alcali*, on being committed to diſtillation.

hath the deleterious quality of ſuffocating animals.

BUT *ſal abſynthii*, and *ſuccus limonum*, are often giving during the ebullition, and, I believe, there can be no inſtance ſhewn of any perſon's being deſtroyed by it, notwithſtanding what we have juſt now ſeen in regard to the ſparrow which was ſuffocated by the vapour ariſing from ſuch a mixture ; therefore, the action of this extricated or factitious air is very different, when applied *directly* to the *lungs*, and when pent up in the *bowels* of a living animal.

THE fear which the *phyſiologiſts* conceived of this deleterious quality in the *ſubtile gas*, and their not well knowing how to diſpoſe of the great quantities of *air* which muſt neceſſarily be thrown off, if the aliment were ſuppoſed to ferment, ſeem to have been he the chief obſtacles that prevented them from embracing the doctrine of alimentary fermentation.

BUT it ſeems now proved, that we have nothing to apprehend with regard to the firſt ; and in reſpect of the latter objection, the experiments above recited, plainly ſhew, that the air which is ſet free, either from a *fermenting*, or from an *efferveſcent* mixture, although it be at firſt truly *elaſtic*, yet is of ſuch a ſurprizing nature as to be capable of returning to a *fixed*, or *non-elaſtic ſtate*, the moment it meets with any abſorbent body that has power to receive it.

AND

AND if we consider that this *air*, which is extricated from the food, has the whole extent of the alimentary canal to spread and diffuse itself through, we shall find that it never can create any uneasiness, * excepting when some acrimonious matter, or other stimulus, though more remote (as in *icteric*, *hysteric*, and *nephritic* cases) occasions a spasmodic constriction in some part of the tube, and prevents thereby the free and equable diffusion of the elastic vapour.

ON the contrary, the usual, natural, and gentle degree of distension is of the greatest importance to the animal œconomy; for it stimulates the muscular coats of the stomach and intestines, and thereby excites, and keeps up, their peristaltic motion, and enables the *lacteal*, and other minute vessels, to *absorb* freely; neither of which (the motion nor absorption) could be well carried on, if the sides

* In habits where the whole system of living solids is too much relaxed, whether from intemperance, profuse evacuations, or previous disease, the muscular fibres of the stomach are apt to yield too freely to the elastic vapour, which is thrown off in the commencement of the digestive process, which must necessarily bring on immediate distress, from the over-distension thus created; but the parties thus afflicted generally have recourse to a speedy, though otherwise dangerous, remedy, spirituous liquors: Drams, when swallowed soon after the meal, not only encrease the muscular power of the stomach, but also retard the alimentary fermentation, and thereby give time, before it be far advanced, or that much air is set free, for the food to pass on into the intestines, where the elastic vapour having so much more room to diffuse itself, no uneasiness or oppression will ensue.

ſides of this long canal had been ſuffered to collapſe. *

THEN, ſo much of it as is left unabſorbed (for we have ſeen that the fermenting mixtures, after a certain time, reſorb the air, which at firſt flies off in an elaſtic ſtate) entering the compoſition of the chyle, it ſtimulates the veſſels appropriated to the carrying of that liquor, and promoting their oſcillatory motion, enables them to pour their contents, in a very ſhort ſpace of time, into the general maſs of blood.

HERE the inteſtine motion is communicated by this active principle, the *elaſtic air*; while every moment it meets with new powers †, which reduce the requiſite proportion to a

 nonelaſtic

*. When all the viſcera of the abdomen are compreſſed by the deſcent of the diaphragm during inſpiration, the chyle contained in the lacteal veins is puſhed on towards the receptacle, becauſe, the valves of theſe veins will not allow it to return back into the inteſtines. Hence, that portion of the lacteal, which lies between the firſt valve, and the orifice that opens into the inteſtine, will be entirely emptied; but the moment the diaphragm aſcends in expiration, and the preſſure is taken off from the contents of the lower belly, the elaſtic air, in the inteſtines, will force the chyle into the aforementioned void ſpaces of the lacteal veins, in the ſame manner, and on the ſame principle, that it raiſes the water in a common pump, while the piſton is lifted up.

This is the way in which M. *Senac* accounts for the abſorption of the chyle.—See his memoir in the *Mem. de l' Acad. R. des ſciences*, for the year 1724.

† This is aſcribed, by Dr. *Hales*, to the ſulphur which is in bodies, and he ſeems to have been led into this opinion from obſerving, that the fumes of common ſulphur have a

nonelastic state, and leave the remainder in possession of its *elasticity*; which is necessary, to maintain the intestine motion, and to serve as a counterpoise to the pressure of the atmosphere.

I AM well aware, that this assertion concerning *elastic air* in animal fluids is directly contrary to the doctrine of *Boerhaave*, who in express terms, condemns the theory of *Borelli*, in relation to this matter.

THAT great man taught, that the air which is found in bodies of all kinds, and particularly in animal fluids, is there in such a state as to be altogether incapable of acting as air: He thought, that it was divided into such extremely minute parts, that its particles were *solitary*, and that, while they remained in this divided and solitary state, they had no power to exert any of the properties of air; but that when two of these particles came within the sphere of each others action, then they acquired the *repulsive power*, and became *elastic*; and being joined by a third, a fourth particle, and so on, they then burst forth in the form of genuine bubbles of air.

BUT

a prodigious power to absorb and destroy the elasticity of air.

But whether it be in reality the sulphur-principle, or phlogiston, as it is now more generally termed, that has the property of fixing, and reducing to a state of non-elasticity, this air, which we find is thrown off from bodies while they are resolving into their several component parts, cannot possibly be determined from any discovery hitherto made. See *Hales's Stat.* vol. ii. p. 108.

BUT as theſe particles are kept in their *ſolitary ſtate* by the weight and compreſſion of ſurrounding matter, or by the preſſure of the atmoſphere, and as they never break looſe but when the texture of bodies is deſtroyed, by fire, efferveſcence, fermentation, or putrefaction; or by removing almoſt entirely, the weight of the atmoſphere, he contended, that the air in animal fluids, ſhould not be regarded as air; neither ſhould we expect it to exert any of its uſual properties; ſeeing that, while life continues, no ſuch changes as thoſe above ſpecified, ever do happen. *

BUT *Hoffman* and Dr. *Hales* are as explicit on the other ſide of this argument; and ſome of the experiments of the latter fully authorize him to be ſo. His opinion is, that there is a "conſiderable quantity of air in vegetables "upon the wing, and in a very active ſtate;" and that this elaſtic air invigorates the juices of both animals and vegetables, while it continues in this ſtate of activity. †

IT appears alſo that the elaſtic air, which is mixed with the animal fluids, always preſerves the ſame tenour with the external air;

 for

* Quin et ratum eſt, aera latentem in liquoribus, non habere illas vires phyſicas quas poſſidet dum extra liquores unitus exiſtit. Igitur in chylo, lacte, &c. adeſt aer naturaliter, ſed ita diſſolutus, atque proinde tandiu non agens ut aer. *Boerhaav. Elem. Chemiæ*, tom. i. p. 519, 524, 525. *Coroll.* 6, 7, & 8. Vide quoque *Prælectiones Academicas*, tom. ii, p. 199.

† See the experiments in the third chapter of the firſt volume of the *Staticks*; and alſo p. 216, 315, of the ſame volume.

for if this were not ſo, the ſides of the veſſels muſt frequently burſt aſunder; ſince even the common changes of the atmoſphere, in its uſual variation, within the compaſs of three inches of the barometer, would make ſuch an alteration of preſſure as no living body could endure. *

BUT when we are told, that the atmoſphere is ſo light on the tops of exceedingly high mountains, that it is ſcarce able to ſuſtain a column of *mercury* of ſixteen inches; † and ſo heavy in the bottom of deep mines, that it can ſupport a column of *thirty-one* inches; and when we know from experience, that a man may

* This difference is calculated by Dr. *Wainewright* to amount to more than a ton and a half (3982 ½ pounds Troy weight.)

† The *French* Academicians, who went to *South-America* in the year 1736, in order to meaſure a degree of the earth's ſurface, found that the Mercury which ſtood in the Barometer at twenty-eight inches (their meaſure) on the ſea-ſhore, fell to leſs than 16 when they aſcended the high mountains in the province of *Quito*.

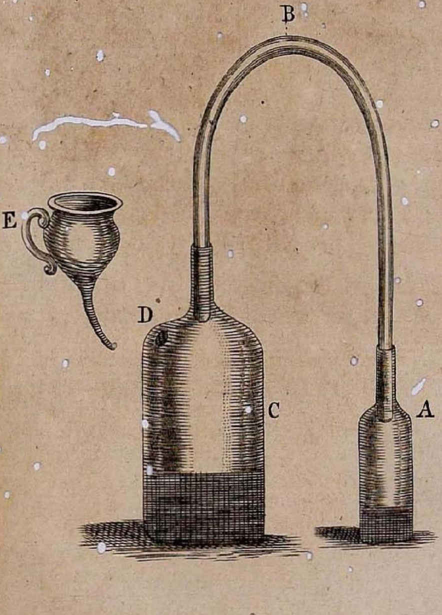
At the city of *Quito* it ſeldom riſes above 20 inches, and yet theſe gentlemen felt no diſtreſs from breathing in ſo light an atmoſphere, except on their firſt going there, when ſome of the company, who had weak lungs, ſpat a little blood, but theſe complaints gradually wore off.

On the mountain called *Pinchincha*, where the Academicians fixed one of their ſtations (for taking the triangles) the Mercury generally ſtood at 16 inches; but one day Meſſrs. *Bouguer* and *de la Condamine*, climbed up to the ſummit of a ſtill higher mountain, named *Choubalong*, where the Mercury ſtood at only 15 inches and 9 lines, being near 12 inches leſs than what it riſes to, on a level with the ſea.

See the voyage de Meſſrs. *Bouguer* and *de la Condamine*, pour determiner la figure de la Terre.

facing p. 52.

Fig. 2.



may *aſcend* in the one caſe, and *deſcend* in the other, and yet feel no great inconvenience, we may be certain that an *equilibrium* is kept up, otherwiſe the veſſels muſt be ruptured in both caſes: In the firſt, becauſe of the expanſive force of the air contained *in* them; and in the ſecond, by means of the immenſe weight of atmoſpheric air preſſing *upon* them. The difference between the weight which preſſeth on the body of a man in one of the *Newcaſtle* coal-pits, and what would preſs upon the ſame man if he were on the top of one of the *Andes*, being calculated to amount to ſomething about eight tons.*

MANY of the phyſiologiſts have imagined, that the animal fluids are furniſhed with air by the lungs; but the objections † againſt this opinion

* The mechanical phyſicians account for this matter by ſaying, that the impetus of the heart increaſes as the reſiſtance to the circulating force of the blood increaſes.

" The weight of the air increaſing, the lungs will be " more forcibly expanded, and hereby the blood more in- " timately broken and divided, ſo that it becomes fitter for " the moſt fluid ſecretions, ſuch as that of the animal ſpi- " rits, by which the heart will be more ſtrongly contracted. " The blood's motion to the ſurface of the body being ob- " ſtructed, it will paſs in greater quantity to the brain, " where the preſſure of the air is taken off by the crani- " um, and upon this ſcore more ſpirits will be ſeparated, " whereby the heart will be ſo ſtrongly contracted as to " carry on the circulation through the paſſable canals, " whilſt ſome other are obſtructed." *Wainewright on the non-naturals*, p. 92.

† They may be ſeen at large in *Haller*'s *Elementa Phyſiologiæ*, tom. iii. and in *Hoffman*, in the chapter *de Sanguinis Circulo per Pulmones*.

opinion are ſuch as cannot eaſily be ſurmounted; they muſt therefore be ſupplied by the way of the *chyliferous canals*, and that in no ſmall quantity; for the air, like all the other conſtituent parts of the animal fluids, will require to be perpetually renewed: old particles will every moment fly off, and new ones muſt of courſe ſucceed.

THERE are many ways of proving the exiſtence of air, in every part of an animal body.

DR. *Hales* found, that "a cubick inch of "hogs' blood, diſtilled to dry ſcoria, produ-"ced 33 cubick inches of air, which air did "not ariſe till the white fumes aroſe." *(Exp. 49.)*

"LESS than a cubick inch of tallow, be-"ing all diſtilled over into the receiver, pro-"duced eighteen cubick inches of air." *(Exp. 50.)*

"HALF a cubick inch of the tip of a fal-"low deer's horn being diſtilled, produced "117 cubick inches of air, which did not "begin to riſe till the white fumes aroſe" *(Exp.* 51.) "Thus it appears, that the "coheſion of animal ſubſtances was not diſ-"ſolved, even in the blood, without con-"ſiderable violence of fire; though it is "ſometimes done to a fatal degree, in our "blood, by that more ſubtile diſſolvent fer-"mentation." *

"SIX-

* As Dr. *Hales* held putrefaction to be only a degree of fermentation, he therefore uſeth the terms promiſcuouſly.

"Sixteen cubick inches of ſheep's blood "being put into a bolt-head, with a little "water to make it ferment the better, in "eighteen days generated 14 cubick inches "of air." *(Exp. 80.)*

So far Dr. *Hales*; but I was deſirous of knowing whether the *fixed air* would paſs from a putrefying, animal ſubſtance, into the *cauſtic* volatile alcali, ſo as to make the ſaid alcali, become *mild* and *effervescent.*

EXPERIMENT 16.

In order to try this, I filled the two ounce phial (A) fig. 3, with freſh mutton, cut into ſmall pieces, and poured in as much water as ſerved to fill up the interſtices; into the neck of the phial, one leg of the bended glaſs tube (B) was inſerted, and cloſely luted; and the other fixed into a little phial (C) containing about a drachm of the ſpirit of *ſal ammoniac* made with *quick-lime.*

The phials thus joined together, were hung up in the common temperature of the air. In four days the elaſtick vapour, in the larger phial, had ſo expanded itſelf, that the liquor was raiſed ſome inches in that leg of the tube which belonged to it, but upon agitation it ſubſided: And this agitation I was afterwards obliged to repeat ſeveral times, otherwiſe the putrid liquor would have run over into the ſmall phial.

When

WHEN they had remained in this ſituation for a fortnight, and that I ſaw the mutton was become highly putrid, I took off the ſmall phial with the alcaline ſpirit, and found, upon dropping in ſpirit of vitrol, that a violent effervеſcence enſued. So that here was a *demonſtration*, that during the progreſs of putrefaction, there is continually ſome volatile matter flying off from the putrifying ſubſtance, and that this fugitive principle is *air*, which is now extricated, and thrown off, from a *fixed* and *non-elaſtic* ſtate, into one that is *volatile* and *elaſtic*; but which, immediately upon meeting with a proper recipient, returns again to its former nature.

THE common notion concerning putrefaction, which is univerſally taught, and as generally believed, is, that bodies become putrid becauſe that *air* hath *acceſs to them*, and communicates ſomewhat; and few people ſeem to have any *idea* that putrefaction enſues in conſequence of the *loſs* of ſome principle; which, however, appears to be the real cauſe. For it will be ſhewn hereafter, that the methods to preſerve bodies from putrefaction and decay depend, almoſt in every inſtance, on *reſtraining the flight* of the *fixed air*; for, as this principle *cements* and *binds together* the conſtituent particles of bodies, rottenneſs, or putrefaction, which enſues in conſequence of the *reſolution* and *diſunion* of theſe particles, will not take place while the *cementing principle* is preſent.

BUT,

BUT, in order to determine somewhat, if possible, concerning this affair, I made the following experiment.

EXPERIMENT 17.

IN the beginning of June, the thermometer being then about 60, I took three little pieces of fresh mutton (of about ℥i) one was put into a tea cup, and melted suet poured all around, so as to cover it intirely; the second was placed under a cupping glass, which rested upon a piece of wet leather lying on the cover of a book; and all the air that could be exhausted was pumped out of the glass, by means of the little air-pump belonging to it; and the third piece of the mutton was left exposed to the open air of the chamber.

AT the end of sixty hours, the piece in the open air, though a good deal dried, was found to have grown evidently putrid. I then went to examine the piece in *vacuo*, and could plainly perceive by its appearance through the glass, that it was become highly putrid, for it had grown mouldy; and upon lifting up the cupping glass, which was now loosened from the leather on which it rested, the smell sufficiently confirmed this appearance, for the putrid stench was by many degrees more offensive and strong than in the piece which had been exposed to the open air.

UPON uncovering the bit of mutton which lay involved in the suet, it was found perfectly sweet.

EXPERIMENT 18.

I RESOLVED, however, to repeat this experiment, and that with a ſtill greater degree of accuracy and attention; and for this purpoſe having provided a tight *air-pump*, I took *four* little pieces of freſh beef; the firſt being weighed, its weight was found to be exactly 458 grains: this piece was placed at eight in the evening (thermometer being at 70) under a ſmall receiver, and all the air that could be exhauſted was pumped out; the ſecond piece weighing 431 grains, was covered with an inverted glaſs of the ſame capacity with the receiver, and reſted on a piece of wet leather, ſpread over the bottom of a China plate; the third piece of the beef, which was nearly of the ſame bulk with the other two, I put into a cup, and poured melted ſuet all around, and over it; and the fourth piece of the beef was hung up in the open air, on the north ſide of the houſe.

WHEN twenty-four hours were elapſed, I took out the piece of beef which had lain in *vacuo*; it had fairly got the offenſive putrid ſmell, and being weighed, was found to have loſt between ſeven and eight grains.

THE piece, No. 2, which had lain under cover, was ſtill perfectly ſweet, and had loſt only two grains and a half.

THE piece in the open air was almoſt dry, and perfectly ſweet.

THE piece covered over with fuet was not examined, as I intended it fhould remain in that fituation for fome days longer.

HAVING placed No. 1 again under the receiver, and exhaufted the air, it was left there till morning; when being again examined, it was found quite putrid, and wanted fifteen grains.

No. 2 had now likewife got the putrid fmell, and being weighed, was found to have loft but five grains in all: fo that the piece which had lain in *vacuo* loft upwards of $\frac{1}{30}$, while the other wanted only $\frac{1}{80}$ part of its original weight.

THIS lofs I looked upon to be chiefly air, for both the pieces appeared and felt as foft and moift as they did at firft; and as they had lain both of them upon wet leather, which is but little adapted to abforb watery vapours, I did not imagine that much of the aqueous part could have been exhaled from either; but the difference of lofs between the two muft have confifted entirely of air, fince the circumftances of both pieces were exactly alike, with regard to the exhalation of their water, both of them being inclofed in veffels of the very fame fize, and both of them alike excluded from communication with the external air.

THE piece which had been expofed to the open air, was found, in thirty-fix hours, to have grown perfectly hard and dry; but was quite fweet, and remained fo, being now rendered incapable of putrefaction, by reafon of the fudden exhalation of its aqueous part;

for, as hath been elſewhere obſerved, there can be no fermentation, and conſequently no putrefaction, without the requiſite quantity of water; for water, by giving fluidity to bodies, allows the other principles to ſhift their places, and to exert their ſeveral peculiar attractive and repulſive powers, which they cannot poſſibly do in a ſtate of too much dryneſs.

AND hence we ſee the plain and obvious reaſon why a moiſt atmoſphere promotes putrefaction; for, independent of the putrefactive *miaſmata*, which are ſometimes contained in it, and which act upon bodies as ferments, at the ſame time that the eſcape of the fixed air is favoured by the ſmaller degree of preſſure, all the water of the putreſcent ſubſtance is left behind; and even in ſome caſes this very water is increaſed, which adds to the fluidity, or ſoftneſs of the body thus expoſed.

HAVING ſuffered the piece which was covered with melted ſuet to remain untouched for three whole days and a night, I opened it, and found the beef perfectly ſound, ſoft, and ſweet; but it grew very putrid in eight or ten hours after it was uncovered, and that a way was made for the fixed air to eſcape.

EXPERIMENT 19.

I REPEATED this experiment again with two pieces of freſh mutton; the weight of the firſt piece, which I put under the exhauſted receiver, was 573 grains; the other, which

was

was covered by the inverted glafs, weighed 554 grains.

AFTER remaining twenty-four hours, I found them both tainted, the weather being at this time very moift, as well as warm; but upon weighing, the proportion held nearly as before; for No. 1 loft more than five grains, while No. 2 wanted only two.

EXPERIMENT 20.

I THEN took two frefh eggs, which had been laid the fame day, and put one of them under the receiver, where it was kept for a week, and the air-pump wrought generally once in the day, in order to keep it as much exhaufted as poffible; the other egg was left in the open air. At the end of the week, I broke them both, and found the one which had been under the receiver, though it could not be faid to be rotten, yet had acquired fome degree of *fœtor*, and the yolk did not appear near fo firm as in the one which had been expofed to the open air.

THE broken eggs happening not to be thrown out, I found the one which had been kept in the receiver of the air-pump quite putrid and offenfive, on the following morning, while the other remained perfectly fweet.

IT is univerfally known, that eggs, when coated over with melted fuet, or fome fuch unctuous matter, will remain frefh and found for many months. * EXPE-

* See the Memoir of M. de Reaumur on this Subject, in the Mem. de l' Acad. for the Year 1735.

EXPERIMENT 21.

WITH the apparatus belonging to an air-pump, there are generally two hemiſpheres of metal, contrived to join cloſely together, ſo as that when the air is pumped out of the cavity, the two remain firmly united by the mere preſſure of the atmoſphere.

IT did not at firſt occur to me, that it would be beſt to incloſe the pieces of meat that I wanted to make the experiments on, in this hollow globe, which promiſed to exclude the external air more effectually than was done in the former way.

HAVING therefore incloſed a piece of ſweet and freſh mutton in this ſphere, and left another, of the ſame bulk, under cover of a glaſs, they were both ſuffered to remain in thoſe ſituations for forty-eight hours.

UPON examination, the piece which had been incloſed in the hollow ſphere was found ſweet, and the other putrid.

UNTIL now, I had been inclined to think that Mr. *Boyle*, and the other writers who aſſert that bodies do not become putrid *in vacuo*, were ſomehow or other led into a miſtake; for as the four preceding experiments plainly ſhewed that putrefaction is accelerated by taking off the preſſure of the atmoſphere, I had almoſt concluded that putrefaction will ſooner take place *in vacuo*, than in the open air.

BUT

BUT on finding from this laſt mentioned experiment (where the vacuum had been more complete, and the communication more effectually cut off than by means of the glaſs receivers) that the piece of mutton incloſed, in the hollow ſphere, did not become putrid in the uſual time, I preſently perceived that the former ones had not been made with ſufficient accuracy.

WE may therefore very ſafely ſubſcribe to the experiments formerly made by Mr. *Boyle*, and ſince repeated with ſtill greater preciſion by the late very celebrated M. *Eller* of *Berlin*, which ſhew that ſubſtances even of the moſt putreſcent nature (ſuch as blood) may be preſerved ſound *in vacuo* for many years.

As taking off the preſſure of the atmoſphere accelerates putrefaction, ſo the increaſing of this preſſure will retard it.

EXPERIMENT 22.

IN the month of *July* I took two pieces of freſh mutton of about half an ounce each, and put one of them into a hollow ſphere belonging to an air-gun,* and by means of the con-

* This air-gun (as improved by Dr. *Ellis*, and made by *Margas*, *Dublin*) is conſtructed in a manner ſomewhat different from the common ones. The chamber for containing the condenſed air not being in the ſtock as uſual (which makes the machine heavy and unwieldy) but it has five or ſix hollow ſpheres belonging to it of about three inches diameter, fitted to ſcrew on to the lock of the gun, theſe ſpheres

condenser which is contrived for throwing air into the cavity of the sphere, I forced in as much as I conveniently could, the other piece of the mutton was put into a sphere of the like sort, but without forcing in any air.

THEY were both laid aside for four days, and then opened, the piece of flesh that had been inclosed in the sphere with the condensed air, was firm, sound, and perfectly sweet; the other piece of the mutton which lay in the sphere without condensed air, was found extremely soft, and highly putrid.

HERE then we have a demonstrative proof that bodies do not putrefy, because that air *adds* somewhat to them; for if they did, then the piece of mutton which lay in the condensed air ought to have putrefied the soonest, because it had the greatest quantity of air applied to its surface.

BUT the reason why condensed air prevents putrefaction is exceedingly obvious and plain from the theory already laid down; since the pressure on every side must force the constituent particles closer together. This of course increases the cohesion, and prevents the intestine motion; and, as hath been already said, without intestine motion there can be no change of combination.

DR.

spheres are contrived with valves to confine the air, which is forced into their cavities, so that a servant can carry them ready charged with condensed air; and thus the air gun of this construction is rendered as light and portable as one of the smallest sized fowling pieces.

DR. *Pringle* having found the *testacea*, and absorbent earths, to be promoters of putrefaction, this seemed the proper time for repeating those experiments.

EXPERIMENT 23.

ACCORDINGLY, I began with chalk, and the *pulv. e chelis cancrorum comp.* of the shops; two phials each with half a drachm of these powders, mixed with an ounce of water, had severally a small bit of fresh beef put into them; a third phial, with nothing but water and a bit of the same fresh beef, served as a standard.

IN thirty-six hours, the two phials with the absorbent powders had both got the putrid smell; in three hours afterwards, the piece of beef in the third phial became likewise fetid.

EXPERIMENT 24.

A LIKE quantity of the chalk and *pulvis e chelis* was put into two phials, with an ounce of water in each, and half an ounce of fresh ox-gall. A third phial, with nothing but gall and water, served as a standard.

IN thirty-six hours, the two first phials were found putrid; the third maintained its sweetness for about six hours longer.

EXPERIMENT 25.

HALF a drachm of the earth of allum, mixed with an ounce of water, and a little bit of fresh mutton, were put into one phial; half a drachm of *magnesia alba*, mixed with an ounce of water, and a bit of the same mutton, were put into a second phial; a third bit of the mutton was left in a cup, with common water, for a standard.

IT was about three in the afternoon that these mixtures happened to be made; they were all sweet at bed-time on the succeeding night, after having stood thirty hours; but next morning, the mutton, in both the *magnesia* and the standard, was found putrid, but the *magnesia* rather more so than the simple water.

THE earth of allum preserved its piece of the mutton twelve hours longer, and rendered it somewhat hard; possibly, some small remains of the acid adhered to the earth, which gave it this slight degree of antiseptic powder.

DR. *Pringle*'s conjecture about the manner of operating of these absorbents, is, that they destroy the *latent acid*.

THIS *latent acid* is supposed to enter into the composition of animal bodies, and is conceived to be one of the chief ingredients in the cement between the particles that constitute the fibres; *chalk* and *testacea*, therefore, act

as

as diſſolvents, by being the proper abſorbents thereof.

THIS *latent* principle, however, is allowed to be ſo much out of the reach of demonſtration, that the doctor ſays, " It may be hard, " or even impoſſible, to produce it in a ſim- " ple form."

BUT there is another principle in animal bodies, of whoſe exiſtence there can be no doubt, the *fixed air*.

CALCAREOUS earths have a very ſtrong affinity with this fixed air; and though, in a natural ſtate, they abound greatly in this principle, yet from their action of haſtening putrefaction, it appears that they are not ſo replete with it, but that they are ſtill capable of extracting ſome from an animal ſubſtance, and thereby promoting the inteſtine motion. For the extraction of *ſome portion* of the fixed air ſeems ſufficient to throw the remainder of that element into action, and thereby to raiſe the inteſtine motion; becauſe, when the fixed air flies off ſpontaneouſly from any ſubſtance, it always reſumes its *elaſticity*, or *repulſive powers*, in the *inſtant* of its extrication; and this *repulſive power* puts the other principles into motion.

BUT when the *whole* of the *fixed air* is withdrawn from a body, by any ſubſtance having a ſtronger affinity therewith, ſuch as *quicklime*, then the *fixed air*, ſo attracted or abſorbed, does *not regain* its *elaſticity*, but paſſeth, in a *non-elaſtic* ſtate, from one body to another;

and hence enſues the *diſſolution*, but not the *putrefaction*, of the body whoſe fixed air is ſo carried off.

EXPERIMENT 26.

I PUT half a drachm of quick-lime into an ounce of water, and immerſed therein a little bit of freſh mutton. This mixture kept off the putrefaction, but it intirely diſſolved the fleſh, in about a week; not the leaſt ill ſmell, however, was to be perceived, although I kept the mixture for three weeks in all.

SEEING then, that *dead bodies* become putrid from the *loſs* of their *fixed air*,* may not the immediate cauſe of putrefaction in *living* bodies be the detachment of too large a proportion of their *fixed air*?

IN

* I have juſt met with a book publiſhed at *Vienna* in 1762, wherein the author endeavours to eſtabliſh a very extravagant theory concerning putrefaction and contagious diſeaſes.

He inſiſts, that bodies which are vulgarly ſuppoſed to putrefy, or to rot, are devoured by myriads of *animalcula*; that the *fætor* ariſing from ſuch bodies ariſeth from the excrements of the ſaid *animalcula*; and that contagion is ſpread by their *ova* being wafted through the air, and carried from place to place.

Hence he attempts to account for the appearances in the ſmall-pox, meaſles, ſcarlet-fever, and all other contagious or infectious diſeaſes; alledging the cauſe of all theſe to be a *materia animata*, or *ſeminium verminoſum*.

The conſequence of this theory is, that *mercury*, and the other *anthelminthics*, are the only things whereby we are to expect to do ſervice in theſe diſeaſes. *Marci Anton. Plenciz Opera Medico-Phyſica.*

IN order to ſee what foundation there may be for this conjecture, let us take a view of the appearances which attend the putrefaction of animal fluids.

DR. *Pringle* remarked, "That both the ſe-" "rum and craſſamentum of human blood" "yielded air, after ſtanding ſome time in the" "lamp furnace, before any offenſive degree" "of putrefaction was perceived."

"I HAVE known (ſays Dr. *Huxham**) the" "whole body ſwell vaſtly, even to the ends" "of the fingers and toes, with a cadaverous" "lividity, though almoſt quite cold, and an" "intolerable ſtench, even before the perſon" "was actually dead; blood iſſuing at the" "ſame time from the ears, noſe, mouth, and" "guts: And this too where the pulſe had" "been very weak and ſmall, though exceed-" "ing quick from the very beginning. Was not" "this from much air generated by the inteſtine" "motion, heat, and putredity, which are" "well known to generate air? Is not the" "*emphyſema* obſervable in ſome ſphacelations," "from the ſame cauſe?"

MANY ſymptoms of this ſort, in the ſcurvy, and other highly putrid diſeaſes, evidently ſhew that the air is actually detached from the blood in theſe terrible caſes.

LET us now obſerve the known cauſes of that degree of putrefaction, which often takes place in the *living body*.

FIRST,

* In his *Treatiſe on the Malignant Sore-Throat*, p. 61.

FIRST, a long continuance in an *over moiſt* atmoſphere is known to bring on the putrefactive *diatheſis*.

AN atmoſphere full of watery vapours obſtructs perſpiration, not only by leſſening the force of the ſolid fibres, and thereby diſenabling them to propel the uſual and natural proportion of perſpirable matter to the ſurface of the body, but ſo much of this matter as is driven on, when it arrives at the proper outlets, finds an *atmoſphere already loaded* with *water*, and conſequently ill adapted, and little capable of abſorbing much of the ſame kind of vapour.

BUT the perſpirable matter conſiſts of other principles beſide *water*; its taſte proves it to contain a large ſhare of *ſalt*; and the reaſon of the thing may warrant us in aſſerting, that it has ſome portion of *earthy*, and *phlogiſtic* or oily matter, in its compoſition; and, in particular, that it carries off a great deal of air *.

THE lighteſt and moſt fugitive part of this excrementitious fluid, that is, its *aerial* part, may be carried off, notwithſtanding the moiſt ſtate of the atmoſphere will not *allow* the *aqueous* part to be exhaled: A great ſhare of the water,

* Cum totum corpus noſtrum innumeris tubulis & poris pervium atque vaſculoſum ſit, per quod, continuo & perenni motu, æſtuantes humores circumferentur, non mirum eſt, ingentem copiam tenuiſſimorum corpuſculorum *aqueo-aereorum*, & *ſulphureo-ſalinorum*, modo ſub forma vaporum, modo humoris, per illud evehi. *Hoffman. Med. Syſt. Rational.* pars iii. cap. vii. ſect. 11.

ter, therefore, and the three other principles joined to it, being left behind, now they are deprived of their air, are in a *putrefactive ſtate*, and conſequently may be become *ferments* to the remaining maſs of fluids.

IF we attend to the known methods of preſerving health, while the body is expoſed to too great a degree of moiſture, the above hypotheſis will appear the more rational; ſince experience teacheth, that this is moſt effectually done, 1, by keeping the body well covered, and wearing ſuch kind of apparel as will moſt readily abſorb the watery part of the perſpirable matter which the atmoſphere cannot abſorb; 2, by uſing ſuch a courſe of diet as will afford the animal fluids more than uſual ſupplies of air, to make up for the extraordinary waſte, ſuch as recent vegetables, fruits, ſugar, and aromaticks; 3, by eating ſparingly of animal food, which yields a ſmall proportion of air, and by abſtaining from the *immoderate* uſe * of ardent ſpirits and fermented liquors, which check the alimentary fermentation, and hinder the free extrication of air from the ſubſtances fed upon.

SECONDLY, if the circulatory motion of the fluids be very much increaſed, either by too violent exerciſe, or by a fever, and this extraordinary motion be continued, putrefaction moſt certainly enſues.

LET

* The moderate uſe of theſe liquors is found to be of ſervice to ſtrengthen and encreaſe the power of the ſolids, and thus enable them to keep up a due degree of perſpiration.

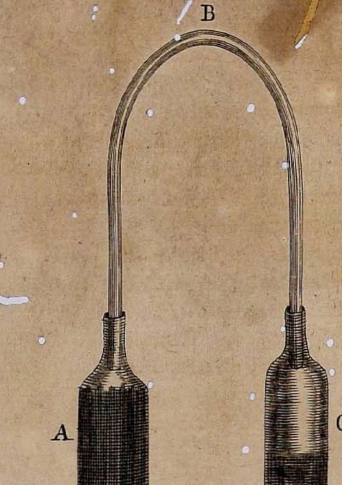
LET the original cauſe of animal heat be what it will, it is certain, that an increaſe of velocity, with reſpect to the circulation, always creates an increaſe of the animal heat. The effects of heat are well known; firſt, in expanding; then, as it increaſes, diſſolving; and at length when raiſed to yet higher degrees, decompounding the ſubſtances which are expoſed to its action. The firſt effect therefore of an increaſe of heat in the living body, is to expand the fluids and diſtend the veſſels, ſo that the red colouring part of the blood gets into ſuch canals as are naturally deſtined to carry only pellucid lymph; but as the heat and attrition increaſe, the texture of the blood is more and more changed, until at laſt it comes to ſuffer an actual decompoſition: for as the inſenſible particles which make up the blood, are eſſentially different from each other, and are held together by the attracting power of ſome one particular principle (alleged to be the fixed air) ſo ſoon as the bond of union comes to be deſtroyed, in conſequence of the increaſe of the repulſive power from the augmented heat, the natural and healthy texture of the blood will be diſſolved, and the particles will run into new and irregular combinations.

THIRDLY, *mercury*, and many of the poiſons, deſtroy the texture of the fluids.

THE action of *mercury* may be conſidered either as breaking down the particles of the blood by its extraordinary weight, and the force

facing p. 73.

Fig. 3.



force of mere mechanical attrition, or it may be ſuppoſed to act in conſequence of its having a power to change the natural laws, which obtain among the repulſive and attractive powers of the ſeveral conſtituent particles: And this laſt ſeems to be the moſt plauſible way of accounting for its operation; ſince the quantity of *mercury*, when rendered active by its being joined to ſome ſaline body, * which is found ſufficient to melt down the blood, is ſo extremely ſmall in many caſes, that no mechanical action, ariſing from its weight, can be deemed equal to the effect. The action of poiſons, to which are to be referred infectious *miaſmata* cauſing putrid diſeaſes, cannot well be accounted for, on any other principle than by recurring to a power of this laſt-mentioned kind; ſeeing their quantity is ſo exceedingly ſmall, that, let them be ſuppoſed to conſiſt of the ſharpeſt of all poſſible darts or *ſpicula*, they

L never

* The reaſon that mercury becomes ſo extremely active, when joined to ſaline bodies, ſeems to be this: It is now rendered capable of the moſt immediate and intimate mixture with the animal fluids, becauſe of the affinity between water and ſalt; and being thus mixed with the maſs of blood, can change the repulſive and attractive powers in ſuch a manner as to produce a new combination among the conſtituent particles.

This accords with the opinion of *Spielmann*, profeſſor of Chemiſtry at *Straſburg*, as appears from his *Inſtitutiones Chemicæ*, a book which I had not ſeen before the firſt edition of theſe Eſſays was publiſhed. "Hydrargyrum vires "ſuas attenuantes & reſolventes, quibus omnia reliqua me-"dicamenta vincit, tunc demum evidentiſſime valeat edere, "quando, ſalium ope, in aqua diſſolubile redditur, & ut "humoribus humanis commiſceri poſſit aptatur." P. 210.

never could occasion such alterations, or destroy the texture of the fluids in such a manner, as experience shews may be done, in a very short space of time, by the introduction of these subtile and active matters into the blood.

FOURTHLY, a diet consisting entirely of animal food, is generaly followed by a putrefactive dissolution of the fluids.

IT is sufficiently known, that animal substances when left entirely to themselves, run very speedily into the putrid state, and notwithstanding it appears, from the 11th experiment of this essay, that the saliva has a power to retard the putrefaction of animal food, yet surely, a diet consisting wholly of such, cannot fail of producing putresent chyle, which, when carried into the blood, will communicate the same disposition to the general mass of fluids; but animal food appears likewise to yield but little air, as may be inferred from remarking the structure of the alimentary canal in carnivorous animals, which is much shorter, has fewer *rugæ*, and does not at all seem adapted to the different degrees of distention, which the stomach and intestines of the creatures who feed altogether on vegetables, or on a mixed diet, are capable of.

THE mechanical physicians think they give a just idea of putrefactive acrimony when they tell us, that it consists in the letting loose of certain sharp pointed particles, which either exist naturally

turally in the fluids (but, in a healthy ſtate, are prevented from doing any harm, by ſheaths or *involucra* which cover them;) or, that theſe pointed particles ariſe from the breaking of the globules, which thus become ſharp and angular, like the others before-mentioned; and, like them, are now capable of tearing, irritating, and deſtroying every thing they meet with. *

BUT the *ſoundneſs* and the *corruption* of animal fluids ſeem to depend more upon *chemical mixture*, than on *mechanical action*; † and yet thoſe chemiſts who made putrefaction and alcali much the ſame thing, and, in conſequence thereof, were to cure all putrid diſeaſes by acids, have not, by this theory, added much to the true improvement of medical knowledge.

DR. *Pringle*, who has thrown great light on this part of medicine, finding from the experiments which he made in the year 1750, that ſyrup of violets was not changed to a green colour by the ſerum of putrid blood; that this ſerum did not make any effervеſcence when

* Vide *De Gorter de Perſpiratione*, cap. vii. p. 42.

† That is to ſay, animal fluids do not contain ſharp pointed or angular particles, that are capable of being obtunded, or brought into the globular form, by merely rubbing againſt each other in the courſe of circulation. But theſe fluids conſiſt of particles which all have their ſeveral peculiar affinities, or attracting and repelling powers, with regard to each other, whereby they are capable of forming a great variety of combinations, in a manner ſimilar to what is obſervable in chemical mixtures.

when ſpirit of vitriol was poured on it; that water, in which corrupted fleſh had been ſometime infuſed, neither effervefced nor changed the colour of the ſyrup; and that alcaline ſalts, both fixed and volatile, powerfully oppoſe putrefaction; could by no means bring himſelf to believe that putrid animal ſubſtances ſhould be regarded as alcaline.

AND the Doctor continued to think ſtill in the ſame manner, until he became acquainted with the experiments made by M. *Caber* of *Turin*; in conſequence of which, with that candour which is inſeparable from the liberal mind, he embraced the very firſt opportunity of acknowledging his miſtake.

HAVING made ſeveral experiments in order to ſatisfy myſelf concerning this matter, I ſhall here lay an account of them before the reader.

EXPERIMENT 27.

HUMAN blood being left in a phial well corked, at the end of two months was found highly putrid; it had not ſeparated into diſtinct parts of *ſerum* and *craſſamentum*, but was all alike thick, being of the conſiſtence of ſyrup, and of a dark red, or rather blackiſh colour.

SPIRIT of vitriol being dropt into ſome of this putrid blood, raiſed a ſmart effervefcence, and converted it into a hardened ſpongy kind of ſubſtance.

EXPERIMENT 28.

Six ounces of this putrid blood being put into a ſmall retort, with two ſpoonfuls of water, were diſtilled by a very gentle heat; about an ounce and half of a tranſparent liquor having come over, the receiver was taken off, and the liquor found to be a ſpirit with a very pungent, and peculiar fetid flavour, not like that of the blood from which it was obtained, but rather more approaching to the ſmell of rotten fiſh.

THIS ſpirit effervеſced violently, with the acid of vitriol.

IT changed the juice of radiſh ſcrapings to a bright green. *

It threw down a white precipitate, from a ſolution of corroſive ſublimate.

IT turned a ſolution of copper in an acid, to a bright blue.

AND when ſaturated with the acid, and its pungency thereby deſtroyed, when ſome fixed alcali was dropt in, the volatile putrid alcali immediately began to fly off, and ſtruck the noſe with the peculiar ſmell, as ſtrong as at firſt.

So that here are all the plain and diſtinguiſhing characters of the volatile alcali.

EXPE-

* The ſcrapings of radiſhes afford a blue juice, which anſwers much better to try acids and alcalies than ſyrup of violets: The moſt convenient way is to dip little bits of linen-rag in the juice, and having dried them, lay them by for uſe.

EXPERIMENT 29.

WITH regard to the putrid bile, the *fœtor* here is not at all like, nor indeed ſo pungent or offenſive, as the ſtench of putrid fleſh or putrid blood; having a greaſy ſmell, not unlike ſtinking olive oil.

PUTRID bile (it was ox-gall that was tried) ſhews no ſign of alcali; it neither effervesceth with acids, nor does it change the colour of the blue juices; neither does it throw down any precipitate from the ſolution of the corroſive ſublimate.

EXPERIMENT 30.

TWO ounces of this putrid bile, being diſtilled by a gentle heat, and two or three drachms of a tranſparent liquor having come over, the receiver was taken off, and the produce found to be a volatile ſpirit, with a peculiar fetid ſmell, and a conſiderable degree of pungency; this ſmell differs from that of the putrid bile itſelf, but approacheth nearly to that of the ſpirit obtained from the putrid blood, though not ſo pungent.

BUT this ſpirit made no effervescence with acids; and when mixed with the ſolution of the ſublimate, it threw down but little precipitate, even leſs than freſh urine did, when mixed with the ſame ſolution; neither did it turn the blue juice to a green colour; ſo that here

there

there were ſcarce any ſigns of an alcali: The only circumſtance wherein it manifeſted the alcaline nature, was when ſaturated with ſpirit of vitriol; for when its pungency and *fœtor* were deſtroyed, by the power of the acid, upon adding the fixed alcali, the peculiar ſmell of the biliofe ſpirit immediately returned.

It being ſummer when I was engaged in the above-mentioned experiments, I could not conveniently get any *human bile*, but when winter came on, and the diſſections began at the anatomical theatre, I ſeized the opportunity of collecting a quantity of that fluid; and having ſuffered it to remain in a corked phial for two months, I then made the following trials.

EXPERIMENT 31.

1. I poured ſtrong ſpirit of vitriol on ſome of the putrid bile, but found it raiſe no ebullition.

Having put an ounce of the putrid bile into a little retort, and placed it in a lamp furnace, I drew off about two drachms of a tranſparent liquor, with a conſiderable degree of pungency, and a fetid diſagreeable ſmell, like the ſpirit obtained from the ox-gall.

2. Some of this ſpirit being dropt into ſyrup of violets, immediately changed the bluiſh colour of the ſyrup into a pale green.

3. When

3. When dropt into a ſolution of corroſive ſublimate, it inſtantly threw down a *white* precipitate.

4. And when dropt into a dilute ſolution of blue vitriol, it cauſed the ſolution to grow turbid, and heightened the blue colour.

5. And yet, notwithſtanding all theſe ſtrong tokens of the *alcaline* nature, the efferveſcence was but very obſcure when ſtrong ſpirit of vitriol was poured on the biliofe ſpirit.

EXPERIMENT 32.

THE putrid liquor which lay about rotten fleſh changed the colour of the blue juices to a dark green. It occaſioned a ſmall precipitation when added to the ſolution of corroſive ſublimate, but it did not efferveſce with the acid, until air was transferred into it, from a mixture of acid and alcali: This method of treatment, not only made it efferveſce, but alſo deſtroyed much of the putrid fætor.

EXPERIMENT 33.

WHEN the fætor of this putrid liquor was deſtroyed, by pouring vinegar upon it, it returned immediately, on the addition of ſpirit of *ſal ammoniac*.

EXPERIMENT 34.

THE ſame thing happened when the fætor was deſtroyed by the pouring of weak ſpirit

of

of vitriol on the ſame putrid liquor, and afterwards dropping in *lixivium tartari*.*

AND thus we find, that as the *fixed alcali* is ſtrong enough to diſpoſſeſs the *volatile*, ſo *both* of them have power to expel the *ſimple putrid alcali*.

FOR, upon the whole, we may ſafely join with *Neuman*, in ſaying, that as ſoon as an animal ſubſtance begins to putrefy, it begins to diſcover an alcaline quality, and this volatile matter, now produced in it, may be ſeparated by diſtillation in a very gentle warmth.

WHEN I made the experiments on the putrid blood, related in No. 26 and 27, I had not obſerved Dr. *Lewis*'s note on the above recited paſſage in *Neuman*: and therefore was greatly ſurprized to find that very ingenious gentleman declare, " That this general doc-" trine of the chemiſts did not appear to " be ſtrictly juſt; and that they ſeemed to " have been mis-led by applying to all animal " ſubſtances what they had found to obtain " in one, but what a farther examination " ſhews to obtain in very few, if any beſides, " at leaſt in any conſiderable degree."

" PUTRID urine (ſays he) gives plain " marks that it contains a volatile alcali, al-" ready generated; but *putrid blood* and *fleſh* " are *not ſenſibly alcaline*, and yield *no alcali* " on

* The acid ſpirit muſt here be pretty much diluted, otherwiſe it will raiſe a more diſagreeable *fœtor*, inſtead of conquering the original putrid ſtench.

" on distillation, till after the phlegm has
" arisen." *

AFTER reading this note, from so experienced a chemist, I began to call in question the evidence of my own senses; and had almost concluded that, some way or other, (though in what I could not possibly guess) the process had been mismanaged.

I THEREFORE determined to repeat it, and that with the utmost caution and exactness.

EXPERIMENT 35.

Two quarts of human blood were put into a retort, which being stopped, was suffered to remain five or six weeks, at the end of which time the blood was found highly putrid; a receiver was now luted on, and the fire raised.

THE very first drachm or two of the liquor that came over was immediately poured out, in order to examine it.

IT had precisely the same smell of the spirit obtained in the former process; it *effervesced* with the *acids*, and shewed all the other alcaline properties already mentioned. †

SOME

* *Neuman's* Chemistry.

† The volatile alcali obtained from putrid substances is not exactly similar to that obtained by violent heat from animal substances not putrid.

It differs remarkably in the flavour, which is nauseous and disagreeable, is not so pungent, and is much weaker, than the common volatile alcali; since this last, as we have just now seen, is capable of dispossessing the putrid alcali, and of driving it off from any body to which it hath been united.

SOME gentlemen of knowledge in chemiſtry were preſent during the diſtillation, and were all thoroughly ſatisfied, that in this matter Dr. *Lewis* himſeif hath been mis-led; and, very poſſibly, in the ſame way that Dr. *Pringle* formerly was, for ſince *alcalies reſiſt* putrefaction, it was reaſonable to conclude, that putrid animal ſubſtances were little, if at all, alcaline.

BUT the principle on which this action of *alcaline ſalts* depends, has nothing to do, in particular, with *alcali*, being, as will be ſhewn immediately, *common* to all *ſaline bodies* whatſoever.

ESSAY III.

ON THE RESPECTIVE POWERS, AND MANNER OF ACTING, Of the different Kinds of ANTISEPTICS.

Although the arguing from experiments and observations by induction, be no demonstration of general conclusions, yet it is the best way of arguing which the nature of things admits of; and may be looked upon as so much the stronger, by how much the induction is more general. NEWTON.

IT was never imagined, until Sir *John Pringle** shewed it, that the *Antiseptic Power* is so extensive; but it appears from the experiments made by that very judicious and learned physician, that *salts of every kind*, whether *acid*, *alcaline*, or *neutral*, *fixed* or *volatile*, as well as the *astringent*

* The Printer had proceeded thus far, before it was publicly known, that Doctor *Pringle* has been most deservedly honoured by His Majesty with the Degree of a Baronet.

gent and *gummy-resinous* part of vegetables, all of them resist, and most of them correct putrefaction; and he pursued this branch of enquiry so far as to enable him to form a table, shewing the comparative antiseptic forces of these several substances.

HIS being so very particular on this head rendered it unnecessary to repeat the experiments, with regard to all these different substances; but as I had got into the habit of experimenting, and found great satisfaction from this method of acquiring knowledge, I resolved to try some of them; and accordingly began with the *acids*, which, from ancient prescription, claim the right of being placed at the head of this class.

EXPERIMENT I.

HAVING diluted the *acids* of *vitriol*, of *sea-salt*, and of *tartar*, together with *vinegar*, and the *juice of lemons*, all, as nearly as I could judge, to the same degree of weakness, leaving them just so strong as to be fairly sensible to the taste, as to change the blue juices into red, and to effervesce plainly, upon the addition of an alcali; I then put some ounces of each into *five* phials, and in every one of them immersed a little bit of fresh mutton; and a sixth phial, with nothing but water and a bit of mutton, served as a standard.

THEY were all placed in a moderate degree of heat (on the top of the furnace, along with the fermenting mixtures of the second table) and suffered to remain for four days.

It

Table III. ACIDS diluted tried as ANTISEPTICS.

ACIDS.	AFTER STANDING 24 Hours.	48 Hours.	3 Days.	4 Days.
(1) Of Vitriol.	Sweet.	Sweet.	Sweet.	Sweet.
(2) Of Sea-Salt.	Sweet.	Sweet.	Sweet.	Sweet.
(3) Of Tartar.	Sweet.	Sweet.	Beginning to putrify.	Putrid; thrown out.
(4) Of Vinegar.	Sweet.	Sweet, and much ſwelled.	Sweet.	Sweet.
(5) Of Lemons.	Sweet.	Sweet, and much ſwelled.	Sweet.	Sweet.
(6) Water, as a Standard.	Smell grown offenſive.	Very fetid.	Putrid, and ſoft.	

It appears by the foregoing table (the 3d) that they were all, excepting the one in the *acid* of *tartar*, and the ſtandard, ſweet at the end of four days. I hung up all the ſweet pieces in the open air, where they ſoon became dry, and remained ſweet.

THUS it appears that acids, even when greatly lowered, have a ſtrong degree of power to reſiſt putrefaction.

EXPERIMENT 2.

ALONG with this parcel of *acids* I tried the *fixed* and *volatile alcalies*, diluted to the ſame low degree; but though the *volatile alcali* preſerved the piece of mutton immerſed in it as well as any of the *acids*, yet the *lixivium tartari* did not keep its ſweetneſs much longer than the ſimple water which ſerved as a ſtandard.

I RESOLVED, therefore, to try the *alcalies*, without lowering them ſo much; and, at the ſame time, was deſirous of ſeeing what ſhare of *antiſeptic power* was poſſeſſed by a *neutral* mixture.

EXPERIMENT 3.

FIVE bits of freſh mutton were put into as many phials, with, 1, *lixivium tartari*; 2, *ſpirit: cornu cervi per ſe*; 3, *ſpirit: ſalis ammoniaci cum calce viva*; 4. *ſpiritus mindereri*; and, 5, *water*, as a ſtandard.

THE

THE four first were all diluted with water, in the proportion of four to one; and all were left in the common temperature of the air.

THE phials were examined every day, for eight days; and all of them, the standard excepted, which grew putrid in three days, found sweet; the pieces of mutton in the *alcalies*, grew soft and white, like fresh fish, but the one in the *spiritus mindereri* always preserved the natural redness of the flesh.

I NOW left off examining them every day, and having laid the phials aside for three weeks, found all the bits of mutton as sweet as they were on the first day.

THE power of the saline bodies was also tried, in another manner.

EXPERIMENT 4.

I PUT four pieces of fresh mutton into as many cups, and poured on them severally, 1, *weak spirit of vitriol*; 2, *spirit of hartshorn*; 3, *lixivium tartari*; and, 4, a *neutral mixture*, of *fixed alcali* and *vitriolic acid*; and having suffered them all to remain about ten minutes, by which time they appeared to be thoroughly soaked and penetrated, I then threw them all into glasses with water, and set them by, in the common temperature of the air. The following table, No. 4, shews how long each of them preserved their sweetness.

Table IV. SALINE BODIES as Oppoſers of Putrefaction.

Spirit of Vitriol.	Spirit of Hartſhorn.	Lixivium Tartari.	Neutral Mixture.	Water, as a ſtandard.
Remained ſweet 28 Days.	Remained ſweet 8 Days.	Remained ſweet 4 Days.	Remained ſweet 14 Days.	Was putrid in 36 Hours.

THUS the power of *ſalts in general*, to keep off putrefaction, was moſt ſatisfactorily proved; and as this power belongs to ſaline bodies *in general*, it certainly muſt depend on ſome property which is *common* to them *all* as *ſalts*, ſince we plainly ſee that *acid* and *alcali* have nothing to do here.

WITH regard to *aſtringents*, Sir *John Pringle*'s experiments ſhew them to be poſſeſſed of a very great degree of antiſeptic virtue, for *allum*, *galls*, *green tea*, and *red roſes*, were all found to reſiſt putrefaction, with a power greatly ſuperior to *ſea-ſalt*.

AND the *gum-reſins*, ſuch as *myrrh*, *aſa fœtida*, *aloes*, and *terra japonica*, together with decoctions of ſuch vegetable ſubſtances as abound in *gummy-reſinous* parts, *virginian ſnake-root*, *pepper*, *ginger*, *ſaffron*, *coutrayerva root*, *ſage*, *valerian root*, and *rhubarb*, *with mint*, *angelica*, *ſenna*, and *common wormwood*, all of them ſhewed great antiſeptic power; [illegible] none of them came up to *camphire*, in this reſpect, which Sir *John Pringle* thinks may be allowed to keep off putrefaction, with a power *three hundred* times greater than *ſea-ſalt*.

MANY of the common eſculent vegetables, *horſe-radiſh*, *muſtard*, *carrots*, *turnips*, *garlic*, *onions*, *celery*, *cabbage*, and *colewort*, were likewiſe found to keep back putrefaction.*

N 2 BUT

* Moſt of theſe, beſide a great variety of other things, have been lately tried in *France*, with reſpect to their powers as Antiſeptics, and the reſult of the whole publiſhed under the title of *Eſſai pour Servir a l' Hiſtoire de la Putrefaction. Paris* 1766. It

BUT as to the antiseptic power of *lime-water*, there appeared to be a kind of dispute, —and therefore,—

(EXPERIMENT 5)

IN order to satisfy myself in regard to this matter, I put a bit of fresh mutton, of two drachms weight, into an open glass, containing some ounces of stone *lime-water*: * It was left there for a fortnight, and at the end of that time was found perfectly sweet; it had indeed grown quite tender, and when it was cut into, and some *spirit* of *vitriol* dropt on it, an effervescence ensued, from the particles of the *quick-lime* which had penetrated the substance of the flesh, and *there* being saturated with the *fixed air*, were now returned to their original state of a *calcareous earth*.

THIS circumstance of the effervescence, may possibly lead us to the *true theory* of the *antiseptic power*, and shew us on what it immediately depends.

WE have seen, by the 16th experiment of the preceding essay, that putrefaction ensues in consequence of the *escape* of the *fixed air*; therefore, whatsoever hath the power to *restrain* the flight of this element, or *hinder* the *intestine motion*, must of course *prevent* putrefaction.

CALCAREOUS

It does not appear who is the author, but the experiments, which are very numerous (not much short of 300) have been made with surprizing patience and accuracy.

* It appears that Sir *John Pringle* made his experiments with chalk, and oyster-shell *lime-water*.

CALCAREOUS *earths*, in their native ſtate, have a ſtrong *affinity* with *fixed air*, and we have ſeen, that upon this account, when they lie in contact with an animal ſubſtance, they attract ſome of this element, and thereby accelerate putrefaction: For here they *cannot penetrate* the ſubſtance of the putreſcent body; they only *ſurround* it: But when theſe earths are calcined, and converted into *quick-lime*, *then* a certain portion of them is rendered *ſoluble* in *water*; the earthy particles, thus minutely divided, are *now* capable of *pervading* the ſoft texture of animal and vegetable bodies; where, as hath been juſt now ſeen, they immediately join themſelves to the *fixed air* of thoſe bodies: So long therefore, as the particles of *lime* remain in this ſituation, ſo long will the *fixed air* remain in a non-elaſtic ſtate, and ſo long will the inteſtine motion, and that particular combination of the inſenſible parts which conſtitutes putrefaction, are kept at a diſtance.

IF *ſaline* bodies * have a ſtrong *affinity* with *fixed air*, which ſeems highly probable, it is eaſy to account for their antiſeptic virtue; for they are all of them capable of ſuch extremely minute

* "For ſince upon the diſſolution of the conſtituent "parts of ſalt by fire, it is found, upon ſeparating and vo- "latilizing the acid ſpirit, that the air-particles do in great "abundance ruſh forth from a fixed to an elaſtic ſtate, it "muſt needs be that theſe particles did, in their fixed ſtate, "attract the acid ſpirits." *Hales*, vol. i. p. 294.

See alſo *Boerhaav. Elem. Chemiæ*, tom. i. p. 531; where there are further proofs that ſalts have a very great affinity with, and are very tenacious, of fixed air.

minute division, that their particles can most easily penetrate into any animal, or vegetable body, and *there*, immediately join themselves to the *fixed air* of those bodies, *where* remaining, they will like the lime, when divided and dissolved in water, keep back putrefaction by *preventing* the *intestine motion*, and *restraining* the *flight* of the *fixed air*.

IF we attend to all the methods that are used to prevent bodies from putrefaction and decay, we shall find that they mostly tend to this single point: Timber is covered over with paint, or some such unctuous and tenacious matter; fruit, * and other green vegetables, are preserved the year round, by slightly scalding them (which thickens their external coats, naturally formed to prevent the escape of their air) and then drying them well, and putting them into bottles closely stopped; flesh meat of all sorts is preserved on the same principle, and may be kept for many months, without much seasoning, provided it be well roasted or baked, and then covered over with lard, butter, or suet; and eggs, it is well known, will remain fresh for a long time, if their shells be coated over with melted suet, or the like tenacious substance.

ANIMAL fluids, likewise, if the air be not suffered to escape from them, remain for a great while, without growing putrid; surgeons often meet with large collections of extravasated blood, or serum, which, after ly-

ing

* Such as apples and gooseberries for baking.

ing for years, in their own firm and compact cyſts, do not betray any thing putrid on their being firſt let out; but in a very ſhort time after the opening is made, and there is a way for the air to fly off, the diſcharge grows intolerably fetid; and they alſo find, where wounds are made in fleſhy parts by ſimple inciſion, and are ſo circumſtanced as to lay them under no neceſſity for frequent dreſſing, that, when carefully kept covered, and the eſcape of the air prevented, they heal in a very ſhort time, without any ſign of ſuppuration, which is a certain degree of putrefaction.

THE various *non-aſtringent* vegetables which Sir *John Pringle* tried, and which he found to retard putrefaction, muſt have done ſo in conſequence of their property to raiſe a fermentation when mixed with any animal ſubſtance; and as to the principle on which *aſtringents* become *antiſeptics*, it is eaſily comprehended.

THE action of *aſtringents* conſiſts in their corrugating, or criſping up the animal fibres, whence the ſolid particles of theſe fibres are brought to a nearer approach, and the power of their coheſion conſiderably increaſed; conſequently, the ſubſtance of the body, ſo acted upon, muſt become more firm, and compact, and this of courſe muſt hinder the *inteſtine motion*, without which there can be no putrefaction.

ALL bodies poſſeſſed of this *aſtringent power*, with regard to the *fibres*, and which, at

at the ſame time, have a ſtrong *affinity* with *water*, muſt be *antiſeptics* on a double account; accordingly, we ſee whence it ariſes, that *ardent ſpirits*, and the ſtrong *mineral acids*, eſpecially the *vitriolic*, reſiſt putrefaction ſo very powerfully: For theſe not only abſorb the *water* from the putreſcent ſubſtance, but likewiſe criſp up its *fibres*, and thereby render it ſo hard and durable, that no change of combination will take place for many years.*

So

* Dr. *Petit* made a number of experiments in the year 1732, with a view to determine the different degrees of aſtringent power in ſuch ſubſtances as are uſually applied to ſtop bleedings, and he obſerved at the ſame time their reſpective antiſeptic powers. His method was to take little pieces of freſh mutton of the exact weight of two ounces, and having covered them over with aſtringent ſubſtances reduced to powder, he left them in that ſituation for four days. At the end of every twenty-four hours, the bits of mutton were taken out, freed from the powders, and accurately weighed; according as he found the weight to diminiſh, he calculated the ſtrength of the aſtringent, for his way of accounting for the action of aſtringents, is, that they abſorb the moiſture from the fleſhy ſubſtances to which they are applied.—"Ils reſſerrent les orifices auxquelles ils s' appliquent parce qu'ils en abſorbent l' humiditè, ce qui "etant fait, les parois des vaiſſeaux diminuees de volume, "ſe rapprochent par leur reſſort naturel, & peuvent ſe "rapprocher au point de ſe coller enſemble & de fermer "le vaiſſeau."

His theory, in relation to the Antiſeptic Power of Aſtringents, is as follows: "La corruption vient de la deſunion "des principes qui fermoient les molecules de la chair ou "ſes parties integrantes; l' humiditè favoriſe cette déſunion, le deſſechment & le reſſerrement y eſt contraire. De "la ſuit manifeſtement, qu'un bon Aſtringent doit laiſſer "la chair, s' il eſt poſſible, ſans corruption & ſans mauvaiſe "odeur." *Hiſt. & Mem. de l' Acad. R. des Sciences*, 1732.

So far in relation to the virtue of things *oppoſing* putrefaction; let us now proceed to conſider thoſe which have the power of *reſtoring ſweetneſs* to ſubſtances actually putrid.

EXPERIMENT 6.

HAVING put a number of ſmall pieces of mutton into a phial with water, and placed it in a moderate degree of heat, in order to make them putrefy the ſooner, I found them, after ſtanding four days, ſufficiently ſoft and putrid; I then put *five* of theſe bits of putrid mutton into as many cups, and poured, on the 1ſt, *ſpirit of vitriol*; on the 2d, *ſpirit of ſea-ſalt*; on the 3d, *vinegar*; and on the 4th, *freſh lemon juice*; the 5th cup contained only water, and was left as a ſtandard, by which the others were to be compared. *

To have a ſynoptical view of the changes from day to day, I formed the following table, No. 5, and at the expiration of twenty-four hours, found the ſeveral appearances exactly as ſet down in the firſt column thereof; after forty-eight hours, the appearances were agreeable to the ſecond column of the table; at the end of three days, things ſtood as in the third, and after four days, the ſeveral bits of the mutton were found in the condition expreſſed in the fourth column.

 BEING

* The mineral acids in this experiment were diluted ſo as to reduce them, as nearly as could be judged, to the ſtrength of the vinegar that was uſed.

Table V. ACIDS tried as Correctors of Putrefaction.

ACIDS of	24 Hours.	48 Hours.	3 Days.	4 Days.
Vitriol.	The bit of putrid flesh was found hard, shrivelled up, and almost sweet.	Entirely sweet; very much shrivelled and hardened.	As on the day before.	As on the day before.
Sea-salt.	Not so much hardened as in the Sp. Vitrioli, nor so much sweetened.	More sweet than on the preceding day, but not entirely sweet.	No change since yesterday.	Putrid smell returned.
Vinegar.	Softened ; greatly swelled, and entirely sweet.	No change since yesterday.	No change.	Grown livid, but still soft and sweet.
Lemon-juice.	Softened ; greatly swelled, and entirely sweet.	No change since yesterday	No change.	Grown perfectly white, but quite sweet.

BEING thus satisfied of the power of *acids* to *correct* putrefaction, I threw out all the pieces of the mutton but the 5th, which had served for a standard; reserving it for another experiment.

THUS it appears, that the *vitriolic* acid has a more powerful antiseptic virtue than the *marine*; and that both of them shew an *astringent* quality, by their hardening animal fibres, though in a different degree; and the effect of the *vegetable* acids, in so remarkably softening and relaxing the solid fibres, gives room to expect great things from their power as resolvents, when outwardly applied.

SINCE *acids* both *resist* and *correct* putrefaction, it was very reasonable to expect that all putrid diseases should yield to them, when given in the way of medicine; but *experience*, the only thing on which the *practice* of *physic* must always rest, abundantly shews that their power in this respect is pretty much limited; and that where the putrid matter to be corrected lies beyond the first passages, *acids* are found quite insufficient to conquer it.

EXPERIMENT 7.

BUT the *alcaline* salts even exceed the *acids*, in regard to the power of correcting putrefaction; for two small pieces of putrid beef, after lying a night in the *volatile alcali*, * diluted

* Both the mild and the caustic alcalies were tried; viz. Spiritus cornu cervi per se, & Spiritus salis ammoniaci cum calce viva.

ted with water, in the proportion of four of the latter to one of the former, were found perfectly free from the putrid ſtench; but they were ſo fully charged with the liquors in which they had lain, that not even boiling could deſtroy the peculiar ſmell of the *volatile alcali*.

EXPERIMENT 8.

THE *fixed alcali* likewiſe ſweetens very powerfully: A little bit of putrid beef, from lying twenty-four hours in *lixivium tartari*, diluted with an equal quantity of water, became hard and firm, and was found to have no ſmell, but that which is peculiar to the *lixivium*.

EXPERIMENT 9.

BUT the *neutral mixture* does not give ſweetneſs: *ſpiritus mindereri*, if made in ſuch manner as to be *perfectly* neutral, ſeems to have no power to correct putrefaction; if the *volatile alcali* is allowed to predominate, the mixture will ſweeten in proportion, for, as hath been juſt now related, the *volatile alcali* is very powerful in driving off the putrid ſtench.

EXPERIMENT 10.

SPIRIT of *vitriol* and *lixivium tartari* being mixed to the point of ſaturation, and a bit of

of putrid beef being left in the liquor for twenty-four hours, was found not at all ſweetened.

EXPERIMENT 11.

A STRONG decoction was prepared, from equal parts, *tormentill root*, *balauſtines*, *pomegranate peel*, and *red roſes*, and a bit of putrid beef was immerſed in the liquor; the *fœtor* ſeemed rather increaſed than diminiſhed, by lying twenty-fours in this decoction.

EXPERIMENT 12.

THE ſame thing happened with *lime-water*, which, notwithſtanding it *reſiſts* putrefaction ſo ſtrongly, appears to have no power to *correct* it.

EXPERIMENT 13.

NEITHER have *ardent ſpirits* the leaſt power to deſtroy the putrid ſtench, any further than as it is, in ſome degree, obſcured by their own peculiar flavour.

EXPERIMENT 14.

STRONG decoctions of the *bark*, and of *valerian*, together with ſtrong infuſion of *camomile flowers*, were alſo tried as ſweeteners. After ſuffering three ſmall pieces of putrid fleſh

flesh to lie thirty-six hours in these liquors, I could scarcely take upon me to say they were sweetened; the putrid stench indeed was rendered more tolerable, by the smell of the liquors, but did not seem to be much conquered.

FOR unless the decoctions be frequently renewed, as was done by Sir *John Pringle*, so as by repeated affusions the viscid particles of the gum-resin may be applied in such quantity as will wholly entangle and fix the volatile particles of the *putrid alcali*, the effect is but small; excepting the putrid body is allowed to remain long enough in the decoction or infusion for a *fermentation* to begin, which will indeed effectually change the state of the mixture, and produce such a new combination as will maintain its sweetness for a considerable length of time.

THIS power of *fermenting mixtures* to *restore* sweetness was discovered by Sir *John Pringle*; but as I have made several experiments in relation thereto, I shall here lay them before the reader.

EXPERIMENT 15.

WHILE the 6th experiment, with regard to the power of acids in correcting putrefaction, was going on, I one evening took a bit of the mutton out of the *store phial*, which was grown, by that time, exceedingly soft and putrid, and having fastened it to a thread, immersed it, at eight o'clock, in a vat of *wash*

wash

wash, at the distiller's, then in a degree of fermentation, rather upon the decline. Next day at noon, I took it out, and having washed it in water, in order to free it from the smell of the liquor in which it had been lying, found it perfectly sweet and firm.

As this piece had been rendered so entirely sweet and firm, and, to all appearance, sound, for it looked like a bit of meat that had been slightly fried, I conjectured that it might not be necessary for it to lye so long as sixteen hours; I therefore obtained a gallon of the wash, from my friend the distiller, that I might examine the progress at home, and at my leisure.

EXPERIMENT 16.

I PLUNGED into this gallon of fermenting liquor the very identical piece of mutton that had served as a standard in the 6th experiment on the acids; and which, from lying in an open cup for several days, was grown so soft that I was obliged to tie it round with a piece of thread (for, when the thread was passed through it, the flesh was so tender that it would not hold) and so extremely putrid that the stench was intolerable.

IN *one* hour the putrid smell was much abated, and at the end of *five* entirely gone, the meat being now firm, and perfectly sweet; it was hung up in the open air, where it soon became dry, and remained sweet ever after.

EXPE-

EXPERIMENT 17.

IN order to ſee whether this change depended on the liquor, or on the vapour, I ſuſpended a thin bit of putrid mutton, from the *ſtore phial*, in the mouth of the veſſel wherein the *waſh* was fermenting, but ſo as not to touch the liquor, and left it there during the night; in the morning it was found plumped up, ſweet, and firm.

THIS experiment I frequently repeated, and always with ſucceſs; but whoever chuſes to try it, muſt take care that the pieces of putrid meat be cut thin, ſo as the vapour may have power to pervade them, otherwiſe the ſweetneſs will not be completely reſtored; whereas, when the experiment is made with the liquor, and the pieces of putrid fleſh are ſuffered to lie ſoaking in it, they may then be cut of any ſize that the party pleaſes; for if time be given, the ſubtile *gas* will penetrate, and produce its effect.

EXPERIMENT 18.

EVEN *acids* will ſweeten pretty large pieces; two bits of putrid beef, of an ounce weight, were left ſeverally in *diſtilled vinegar*, and in *melaſſes waſh*, juſt as it had done working.

THE firſt was found very much, though not entirely, ſweetened, after lying twenty-four hours; but the ſecond was ren-

dered perfectly ſweet. In order to ſee if they were thoroughly penetrated, and ſweetened to the heart, I boiled both the pieces, and was ſurprized to ſee the one which had lain in the *acid* go all to pieces in the boiling, which I thought the more odd, as it had been rendered hard and firm; an effect wherein the *diſtilled* vinegar differs widely from that which is *not* diſtilled. This diſſolution I aſcribed to the peculiar *diſſolvent quality* of the vinegar, and did not believe, until I tried it, that a *mineral acid* would produce the ſame effect.

EXPERIMENT 19.

BUT an ounce of putrid beef, after lying twenty-four hours in *dilute ſpirit* of *vitriol*, and coming out perfectly hard, ſweet, and contracted, on being boiled, fell all to pieces, exactly as did the one which had lain in the diſtilled vinegar; and when rubbed between the fingers, it melted away like ſo much wet paſte. To be certain that nothing of this was owing to too much boiling, I put a little bit of beef, of a drachm weight, that had been ſweetened by the *volatile alcali*, into the veſſel along with it, and ſuffered it to remain the whole time of the boiling; but it came out white and firm, and, as hath been mentioned already, ſtrong of the *volatile alcali*.

FOR the *alcalies* cannot be ſaid, with *propriety*, to *reſtore* ſweetneſs; they only drive off a *weaker* alcali: As the *fixed* alcali can diſ-

P poſſeſs

possess the *volatile*, so both of them have the power to drive off the *simple putrid* alcali; and thus the putrid substance becomes the *basis* of a *stronger*, instead of a *weaker*, alcali.*

THE manner in which *acids* sweeten putrid flesh seems also pretty plain; for their action appears to consist in *saturating* and *fixing* the *putrid alcali*, and by thus destroying its *volatility*, they hinder the putrid *fætor* from flying off, and striking the organs of smell; but at the same time that acids do this, they *dissolve* the *elementary earth*, and thus destroy the texture of that substance whose soundness they were supposed to restore. Whereas, the peculiar excellence of the fermenting liquors is, to restore sweetness to the fluids, and firmness to the solids.

EXPERIMENT 20.

Two pieces of linen rag were dipt in the putrid liquor of the *store phial*; one was suspended over the *wash* in fermentation, and the other was hung up in the open air. In two hours the one exposed to the *vapour* became almost sweet, the other remaining as offensive as at first; and in six hours, the first piece of rag had no smell but that of the vapour; while the other, thought now grown dry, still strongly retained the putrid stench.

As sugar is an antiseptic, in consequence of its saline nature, I did not know but somewhat of

* See the 28th, 30th, 33d, and 34th experiments of the preceding essay.

of the virtue of the *melasses wash* might depend on this cicumstance.

IN order to determine this, I immerged one small bit of putrid flesh in a mixture of bread and mutton, with lemon-juice, and suspended another in the neck of a phial containing a fermenting mixture, with spinage; and found, after eight hours, that both of them had lost the putrid stench, and had now no other smell than that of the mixture; which, as hath been elsewhere observed, was sweetish, and not unlike fenugreek seed. The like experiment was tried with another fermenting mixture, as the reader will find by turning back to the 35th page.

Sir *John Pringle* seems to think, that the putrid smell in these mixtures is destroyed by the *acid* which is produced in the course of the fermentation. Relying on his authority, I was for some time of the same opinion, and looked on the *subtile gas* as somewhat of the nature of a *volatile acid*; for I had *then* the *ideas* of *acid* and *antiseptic* strongly connected together in my mind: but, upon enquiry, this notion was found to be void of foundation.

EXPERIMENT 21.

FOR one piece of linen rag dipped in *lixivium tartari*, and another tinged *blue* by the scrapings of *radishes*, where exposed for eight-and-forty hours to the vapour arising from a large vat full of melasses wash, in high fermentation;

mentation; yet the first was not at all saturated, nor the last, in any, even the slightest, degree changed red.

AND in all the fermenting mixtures that I tried, none of them became sour, excepting one (No. 6, table 1) for several days after the first stage of the fermentation had ceased.*

EXPE-

* In order to see how long this kind of mixtures would preserve their sweetness, I reserved three of the 14th experiment of the second essay; to wit, those with the barley, the rice, and the oats.

Into the phial with the barley I put about half an inch of a thread which had been dipped in a putrid animal fluid; into the one with the rice I poured a teaspoon-ful of vinegar; the third, with the oats, was left without any addition.

All the three mixtures were now at rest, having run through their first stage, and being every one perfectly sweet, they were left in the common temperature of the air; the phials not closely stopt. (This was in the month of *July*.)

For three weeks, no alteration was perceivable in any of them; but at the end of that time, the mixture into which the putrid ferment had been put began the intestine motion, which continued, in a gentle degree, for seven or eight days before the mixture became fully putrid.

The phial into which the vinegar had been thrown, began, at the three weeks end, to shew some small signs of intestine motion; a thick, white scum formed on the surface, and it did not grow putrid until it had stood, in all, six weeks.

The third mixture, to which nothing had been added, remained quite at rest, without shewing any signs of motion for two months; then it was found to have grown sour, and had contracted acidity sufficient to curdle milk, and to raise an ebullition when some salt of hartshorn was thrown into the phial.

I now corked the phial, and set it aside for three months; and then, having distilled the mixture by a very gentle heat, I obtained a *volatile alcaline spirit*, of a peculiar smell, not unlike that obtained from the putrid blood formerly mentioned.

EXPERIMENT 22

Two drachms of the *cortex* in powder, and half an ounce of *ſaliva*, were added to a mixture of *ox-gall* and *water*, which was grown *putrid*, for it had been uſed as a ſtandard to two mixtures of gall and *teſtacea*.

UPON the firſt mixture, the *fœtor* increaſed greatly, and the bark ſeemed to act on the putrid bile in a manner not unlike the action of *lime*, or *fixed alcali*, when mixed with *crude ſal ammoniac*, in order to drive off the *volatile alcali*.

THE mixture was now laid by for twenty-four hours, at the expiration of which I found the putrid ſmell much abated, and a fermentation beginning; I now ſuſpended a little bit of putrid fleſh in the neck of the phial, and placed it in a moderate degree of heat. When twenty-four hours more were elapſed, I again examined the mixture, which was ſtill in briſk motion, and found that it had entirely loſt the *fœtor*, having now acquired a new and peculiar ſmell, which was not only ſweet, but agreeable, and different from the original ſmell either of freſh bile, or of the *cortex*.

THE bit of putrid fleſh was found ſweetened; having removed it, I fixed the bended glaſs tube as deſcribed formerly, and, by means thereof, joined a ſmall phial, containing a drachm of *non-efferveſcent*, *volatile alcaline ſpirit*, to the phial which held the

the fermenting mixture: They were left in conjunction for twenty-four hours, and when separated, some *spirit of vitriol* being dropped into the small phial, raised a smart ebullition.

IT has been shewn in former experiments, how readily the *bark* runs into fermentation out of the body, and there is great reason to expect that it will be still more prone to ferment in the body, when opened by the digestive fluids; and the present experiment shews plainly, that when opened by fermentation, the *cortex*, like the *melasses*, and other things that were tried, gives out some subtile matter, which hath the power of restoring sweetness to putrid animal substances: Is it not agreeable then to reason, as well as experiment, to account for some share of its *antiseptic* virtue upon this principle?

IF we attend to the nature of the diseases wherein the bark is found most useful; and, on the other hand, remark those cases wherein it either does harm, or proves of no effect, we shall find some ground for establishing this *hypothesis*.

FIRST, the *cortex* is of the highest service in *gangrenes*, where the vessels are relaxed, and the blood dissolved; 2, in wounds and ulcers, where the solids and fluids are in the same weak and dissolved state; 3, in the low state of malignant fevers, and small-pox, where the humours are evidently putrid; 4, in intermittent fevers, where almost every symptom betrays evident marks of a putrefactive acrimony.

IN

IN these last it seems to be the most plausible opinion, that the morbific matter is lodged originally in the flexure of the duodenum; here the *cortex* comes into immediate contact with the putrefactive *colluvies*, and *presently* † running into fermentation, soon throws off a quantity of the subtile vapour; sufficient to saturate the acrimonious matter; which being thus rendered mild and sweet, the febrile commotion, which would have ensued had this irritating cause not been removed or corrected, is now prevented.

IN this case, we have supposed the general mass of fluids to be untainted; but, even in cases where the putrefactive acrimony has made further advances, and has actually taken place in the constitution, if the medicine be continued, and given in large quantities, its salutary effects will presently appear, and will shew that the *antiseptic vapour* can reach the blood, and *there* restore its consistence, and correct its sharpness.

BUT this valuable drug has another great advantage. Beside its readiness to ferment, and being able to yield a large proportion of the *antiseptic vapour*, it hath also a remarkable power of bracing up and strengthening the vascular system; thus enabling the powers of the body to concoct the morbific matter, and expel it by the proper emunctories: For it is observable,

† The putrid matter will encrease the tendency to putrefaction. Thus we see how well it is adapted to work out its own cure, provided it be supplied with proper materials.

obſervable, that, after a liberal uſe of it, profuſe evacuations of urine and ſweat often enſue, and ſometimes beneficial diſcharges by ſtool; then, when the offending matter is ſo thrown off or corrected, the aſtrictive quality of the bark braceth up and ſtrengthens the ſolid fibres, which had been relaxed and weakened by the putrefactive acrimony.

BUT in diſeaſes where there is an inflammatory tendency, where the veſſels are full, the fibres tenſe and rigid, and the blood thick and ſizey, then is the bark hurtful and dangerous; becauſe, it throws *much air*, and *no water*, into the blood and conſequently muſt highly increaſe the morbid diſpoſition of the fluids, while, at the ſame time, its aſtringent virtue muſt add to the *tenſion* of the *living ſolids*.

FOR this *ſubtile antiſeptic vapour* appears to conſiſt chiefly, if not altogether, of the *fixed air* * of the fermenting ſubſtances; ſince I have found,

* This, I find, is not admitted by Dr. *Cullen*, the celebrated profeſſor (late of chemiſtry, but now of the theory of medicine) at *Edinburgh*; for he teaches (as I am imformed) that there is a volatile acid which flies off from fermenting and effervefcent mixtures along with the aerial principle, and that it is this acid which deſtroys the putrid fœtor, while the air reſtores firmneſs to the pieces of rotten fleſh. This *volatile vegetable* acid is ſaid to bear the ſame relation to the *fixed* vegetable acids, that the *volatile* vitriolic does to the *fixed* vitriolic.

But it ſeems that this volatile vegetable acid has not the power to change the blue juices to a red colour, nor to ſaturate the alcaline ſalts; therefore, the 21ſt experiment of this eſſay is, by no means, concluſive, and has led me into an error, in aſcribing the power of reſtoring ſweetneſs chiefly to the aerial principle.

found, by experiment, that as the *fixed air* thrown off by *effervescence* agrees with the *gas sylvestre*, in *suffocating animals*, so does it agree with the same *gas*, in the property of *restoring sweetness*.

EXPERIMENT 23.

A SMALL piece of putrid beef, taken immediately from the liquor in which it lay, was put into a cup with some *lixivium tartari*, and on it was poured by degrees, a sufficient quantity of *spirit* of *vitriol*.

THE moment the saturation was complete, the bit of beef was taken out, and found to have almost entirely lost the putrid *fætor*; what smell it now had, was rather to be termed musty than putrid; on washing it in clean water, this musty smell went off, and a very little of the putrid was again to be perceived.

EXPERIMENT 24.

ANOTHER bit of the same putrid beef was put into a cup, with some *salt* of *hartshorn*, and on them vinegar was poured, to the point of saturation: Immediately on the cessation of the ebullition, the piece of flesh was taken out, and found to have *entirely* lost the *fætor*, having now no smell but that of the neutral mixture, which is not unlike the smell of burnt horn; but upon washing the beef, this smell went

went off in great meaſure, and not the leaſt of the putrid ſtench was to be perceived.

BOTH theſe pieces were boiled, and both came out perfectly firm; the laſt piece, upon being cut into, was found ſweet to the very heart; but the other was found not to have been ſo thoroughly pervaded, as it diſcovered a little of the putrid ſmell on being divided.

EXPERIMENT 25

A BIT of putrid fleſh of about a drachm, was put into the phial C, as in figure 2, which previouſly had a drachm or two of *ſal cornu cervi* thrown into it, the glaſs tube was fixed cloſely into the neck of the phial, and the other extremity of the tube inſerted into a ſmall phial, with half a drachm of the putrid liquor that lay about the rotten fleſh; vinegar was now poured through the funnel, to raiſe an ebullition. When the ſalt was all diſſolved, and the effervescence at an end, the phials were ſeparated; the bit of beef was now found ſweet, and the putrid liquor, which before ſhewed no ſigns of ebullition upon dropping an acid into it, *now* effervesced plainly, on the addition of *ſpirit* of *vitriol*; and it had beſides loſt much of the putrid *fœtor*.

AND thus we ſee, that fermenting and effervescent mixtures are the moſt powerful of all known *antiſeptics*.

SOME ſhare of this power remains in liquors after they have run through their firſt ſtage of fermentation,

fermentation, which is different in different liquors; as may be ſeen in the following table (No. 6) and ſeems to depend on the quantity of the ſubtile vapour which is left in the liquor, for thoſe that are moſt ſparkling and briſk, are found to poſſeſs the greateſt ſhare of antiſeptic power. *

THE *fixed air*, when transferred from a ſound body into one that is putrid, appears to reſtore to that body the *principle* that had been deſtroyed or loſt. †

BUT here it may be demanded, what can theſe experiments prove with regard to the reſtoration of putrid fluids, in a living body; is it poſſible to ſaturate theſe humours with ſuch a quantity of air as will be ſufficient to *correct* their *ſharpneſs*, *reſtore* their *conſiſtence*, and *bring back* their *ſweetneſs* ?

To this it may with ſafety be replied, that it is not only poſſible, but that it is, perhaps, the only way by which this change can be produced.

FOR we have ſeen that there is a deception, in regard to both *acids* and *alcalies*, when we

Q 2 ſuppoſe

* "When, by fermentation, the conſtituent parts of "a vegetable are ſeparated, part of the air flies off into an "elaſtic ſtate; part unites with the ſalt, oil, and earth, "which conſtitute the tartar; the remainder, which con-"tinues in the fermented liquor, is there, ſome of it in a "fixed, and ſome of it in an elaſtic ſtate." *Hales*, vol. i. p. 300.

† The manner of acting of air, when transferred into a body whoſe texture is broken and diſſolved, will be better comprehended from ſome experiments hereafter to be mentioned in the 5th Eſſay; the thing being, in ſome degree, rendered viſible.

Table VI. COMMON FERMENTED LIQUORS tried as Sweeteners of Putrid Flesh.

Claret.	Lisbon White Wine.	English Cyder, (bottled.)	Common Dublin Ale.	Melasses Wash, (newly fermented.)	Sugar and Water (not fermented.)
At the end of 30 hours, the bit of putrid meat was found perfectly sweet and firm.	At the end of 12 hours, the bit of meat was found perfectly sweet.	At the end of 8 hours, the bit of meat was found quite sweet.	After 24 hours not at all sweetened. *N. B.* This kind of ale is but of the weaker sort, and generally not very brisk.	In 24 hours, the bit of putrid meat became perfectly sweet.	After 24 hours, not at all sweetened.

ſuppoſe them to reſtore ſweetneſs to a putrid animal ſubſtance; that the *firſt*, ſo far from giving ſoundneſs to ſuch kind of ſubſtances, do in reality deſtroy their *texture*; and that the *ſecond* only change the nature, but do not reſtore the original ſweetneſs.

BUT *acids*, we have likewiſe ſeen, are *neutralized*,* during the alimentary fermentation, and therefore they cannot act as acids, by ſaturating any thing of the *alcalious* kind that they meet with in their courſe of circulation. The power of *acids*, therefore, is confined, and we are not to expect, that they are to pervade the minute branches of the vaſcular ſyſtem, when indeed, it is evident, that they *ought not* to be allowed to paſs into the *blood* in their *acid form*, ſince it is plain, that, from their diſſolvent nature, the body muſt be deſtroyed, and its moſt ſolid parts melted down to a jelly, if *naked acids* were to be received into the general maſs of fluids: † Their action, therefore, cannot extend beyond the limits of the alimentary canal, where they may come into contact with, and correct the ſharpneſs of a putrid colluvies. In theſe caſes they may, and actually do, exert very notable powers, as is often experienced, by their preventing ſickneſs and nauſea, and reſtraining vomitings; and

* See the 3d and 5th experiments of the 2d Eſſay.

† In thoſe deplorable caſes that now and then happen, where all the bones become ſoft, a manifeſt acidity hath been diſcovered in the fluids; a thing ſeldom obſerved in other morbid caſes. See *Haller. Element. Phyſiolog.* tom. ii. p. 94.

and by neutralizing, as it may be termed, the putrefactive matter, thus prevent it from carrying into the blood its peculiar destructive quality.

WITH regard to the exhibition of *alcalies*, the point is not yet thoroughly settled. There can be no doubt of their power to resist and correct putrefaction, in *dead bodies*; but whether, upon the presumption of this virtue, they can be given with propriety, as antiseptics, is not so clear.

A VERY eminent and successful practitioner is of opinion, "That the exhibition of volatile "alcalious salts to the sick, in putrid diseases, "is adding fuel to the fire; for they certainly "dissolve or break the globules of the blood, "and thence more speedily bring on the "general putrefaction." And he relates a singular case, where an uncommon quantity of *salt of hartshorn* being taken by a young gentleman, and the use of it continued, "An "hectic fever ensued, as also vast hæmorrha-"ges from the intestines, nose, and gums; "every one of the teeth dropped out, and "the patient could eat nothing solid; he "wasted vastly in his flesh, and his muscles "became as soft and flabby as those of a new-"born infant; and broke out all over his "body in pustules, which itched most in-"tolerably, so that he scratched himself con-"tinually, and tore his skin with his nails in "a very shocking manner; his urine was al-

"ways

"ways exceſſively high-coloured, and very "fœtid." *

THE acrimony † in this caſe however appears to have been what *Gaubius* terms *acre alcaleſcens volatile purum*, which, though a component part, is not to be confounded, or looked on as the ſame, with the real and genuine putrid acrimony ; this ſeeming to conſiſt, in an over proportion, and irregular combination of the ſaline and oily particles of the blood ; theſe particles being left at liberty to run into this deſtructive combination from the want of their bond of union, the fixed air.

ASTRINGENTS, as hath been ſhewn, prevent putrefaction very powerfully, but we find that they have not the leaſt degree of power to correct it.

BUT putrefactive acrimony firſt takes place in the *fluids*, and it is on account of *their* indiſpoſition, and the deſtructive and irregular combination of *their* particles, that the texture of the *ſolid fibres* is weakened, and their coheſion impaired ; therefore, bracing up and ſtrengthening the ſyſtem of ſolids, while the maſs of fluids continues in the morbid ſtate, can avail nothing ; it is beginning the cure where it ought to be concluded.

ASTRINGENTS, therefore, as *antiſeptics*, can only be of importance in thoſe caſes, where, from extreme relaxation and reſolution of

* *Huxham on the Sore Throat*, p. 67 & 68. See also his *Eſſay on Fevers*, p. 118, 5th Edition.

† *Vide Gaubii Inſtit. Path.* ſect. 310 & 312.

of the ſolids, the diſſolved fluids are ſuffered to tranſude, and either form ſpots of different hues, or run off by actual hæmorrhage; here indeed, the *acids* of *vitriol* as an *aſtringent*, *not* as an *acid* (for *vinegar* would do nothing in this caſe) is found of great uſe, in *gaining time*; either, till the powers of the animal œconomy correct the morbid diſpoſition of the fluids, or that the ſame thing is brought about by the virtue of ſome efficacious *antiſeptic*, ſuch as the *cortex*, which is the thing uſually joined with the *ſpirit* of *vitriol*, and that with the greateſt propriety, on account of its own aſtrictive quality, as well as extreme readineſs to run into fermentation; which is the circumſtance that conſtitutes a true and genuine antiſeptic.

THE phyſician who gives aſtringents in theſe caſes, and with theſe views, acts not unlike a ſurgeon who ſecures and ties the blood-veſſels that are divided in the beginning of an operation, in order to allow himſelf ſufficient time to finiſh it with ſafety and regularity.

THAT the credit which *acids* have gained as *antiſeptics*, hath reſted much on the ſucceſs attending their exhibition in the circumſtances above-mentioned; and that they really act in theſe caſes as *mere aſtringents*, may be found from a cloſe attention to the progreſs of the cure.

LET any one read the very remarkable caſe in Dr. *Huxham*'s Treatiſe on Fevers (p. 62) and it will plainly appear that the *acid* of the

vitriol

vitriol braced up the fibres, checked the transudation of the diſſolved blood, and thus obtained a truce until the repeated doſes of the *cortex*, " the *rice*, the *panado*, the *ſago*, " the *bartſhorn-jelly* well acidulated, and the " *toaſt* out of *claret* and *red port-wine*," generated enough of the *antiſeptic vapour* to ſaturate and correct, in ſome degree, the putrefactive acrimony, whereby the patient was enabled to get upon his legs, when exerciſe, and a proper diet, reſtored him to his perfect health. *

To ſhew this ſtill further, in a caſe no leſs deplorable, I ſhall give the following, communicated by Dr. *Archer*, phyſician to *Stevens's Hoſpital* in *Dublin*.

" *THOMAS BROWN*, a robuſt countryman, of about twenty-four years of age, was admitted, the firſt of February, 1762, a ſurgical patient into Dr. *Stevens's Hoſpital*, for an *Herpes exedens*, which extended from the nape of the neck to the inferior part of both *ſcapulæ*. After having been purged, on the 5th he was ordered to take ten grains of the blue pill every day, which he did until the 25th; ſo that in this time he had taken near two hundred grains of *mercury*, without any appearance of ſalivation. †

R ON

* There is a caſe in *Sydenham* equally ſtrong in regard to this point; it was communicated by Dr. *Goodall*, and is to be found in the Letter to Dr. *Cole*, concerning the ſmall-pox and hyſteric diſeaſes.

† This blue pill uſed in Stevens's hoſpital conſiſts of ſo- thing

"ON the 26th, he complained of ſickneſs in his ſtomach, entire loſs of appetite, and great wearineſs; the ulcer had not mended; he was therefore confined to his bed, and ordered to drink plentifully of warm diluting liquors. The 27th, there appeared numerous *petechiæ* on his whole body. The 28th, the number of theſe increaſed, and appeared livid. The 1ſt of March, he had a hæmorrhage from the noſe, which was attempted to be ſtopt by different ſtyptics; but theſe cauſing him to ſneeze, rather increaſed the bleeding: The ſame evening he was ordered a vomit, which he took, and another next morning; by theſe the bleeding likewiſe encreaſed.

"THE apothecary of the houſe (it not being the phyſicians' viſiting-day) then ordered him three ſpoonfuls of the following mixture, to be taken every two hours.

℞. *Aq. Menth. vul. Sim. Tinct. Roſar. cum triplici quant. Sp. Vitriol.* aa *uncias tres, Tinct. Cort. Peruv. uncias duas, Tinct. Martis in Sp. Salis, Seſcunciam, M.*

"THIS, he ſaid, reſtrained the hæmorrhage; but, on the 3d, blood came away abundantly in his urine.

"HE continued the above mixture until the 4th, when I was deſired to ſee him: I found him greatly exhauſted, his pulſe quick and weak,

th[illegible] out crude mercury, and as much Venice turpentine as is ſufficient to extinguiſh the quickſilver.

weak, frequently ſpitting black coagulated blood, his urine the colour of blood, his body thickly covered over with *petechiæ*, red and livid, which here and there ran into *vibices*, as if he had been ſeverely ſcourged.

"I ORDERED him to take a drachm of the *cortex* every hour, waſhing it down with four ounces of the *infuſum amarum* of the London diſpenſatory, with thirty drops of the *acid elixir* of *vitriol* in each doſe.

"AFTER taking a few doſes, he imagined himſelf better; and therefore, of his own accord, took it every half hour. The 7th, the blood diſappeared from his urine, and greatly abated from his mouth and noſe; the livid *petechiæ* changed to red, and the *vibices* into diſtinct *petechiæ*. The 11th, all the hæmorrhages ceaſed, and the petechiæ had almoſt diſappeared. On the 15th, they were entirely gone. He continued his medicine, however, until the 27th; on which day, his *herpes* was completely ſkinned over. During this time, *viz.* from the 3d to the 27th, he took *fifteen ounces* and ſix drachms of the *cortex*."

THE antiſeptic virtue of the other gummy reſinous vegetables, if we may judge of them all by this capital one, the *cortex*, appears alſo to depend on their fermenting in the body; and as theſe ſubſtances contain a large proportion of the *fixed air*, they muſt part with much of it in the courſe of their fermentation: For now that we have taken a view of the ſeveral kinds of *antiſeptics* and have ſeen how

 much

much the action of *ſalts*, and of *aſtringents*, is limited, we find that the only dependence muſt be on thoſe things which throw a *great quantity* of *air* into the blood, if we expect to work a complete change on the whole maſs.

IF we attend alſo to the things that *prevent* putrefaction in *living* bodies, we ſhall ſtill find that the dependence is on the quantity of *air*.

THERE can be no doubt but that it is the vegetable part of our food which yields by far the greateſt ſhare of the air, that enters the compoſition of the animal fluids; and *vegetable food* moſt certainly prevents the *putrefactive diatheſis*. Sir *John Pringle* aſcribes it, and with great juſtice, to the frequent uſe of freſh vegetables and ſugar, which now make up ſo great part of the diet of the *European nations*, that we at this day ſo ſeldom hear of the dreadful putrid diſeaſes which formerly ſwept off ſuch multitudes, every thirty or forty years, and generally went under the name of plagues.*

THE effects of being deprived the uſe of freſh vegetables, are ſtrongly manifeſted in the fatal ſcurvies, fevers, and dyſenteries, to which ſeamen, and people pent up in garriſons, are often ſubject: In ſhort, this matter is ſo well known, and every body is ſo ſenſible of it, that it would be a treſpaſs on the reader to inſiſt on every particular inſtance; I ſhall therefore only requeſt, that he may obſerve,

* See alſo *Hoffman*, in the chapter *de Venenis in Aere Contentis*, &c. ſect. 26.

ſerve, in general, the kind of diet which is moſt wholeſome in hot climates; that it muſt, in order to preſerve health, conſiſt very much of vegetables, and of thoſe kinds which produce the greateſt quantities of air, in order to afford a ſufficient ſupply of *antiſeptic vapour*, to make up for the extraordinary waſte of air which is carried off from the fluids by profuſe perſpiration; and that thoſe people muſt inevitably fall into putrid diſeaſes, who eat much animal food, which produceth but little air; who drink much ſpirituous liquors, that contain no air themſelves ſcarcely, and prevent the ready extrication thereof from the aliment, during the digeſtive proceſs; and who incautiouſly expoſe themſelves to a moiſt atmoſphere, which hinders any thing but the *aerial* part of the perſpirable matter to be carried off.

THIS general and well-known *antiſeptic* quality in *vegetable food*, is commonly accounted for by ſaying, that it produceth *aceſcent chyle*; but *alcaleſcent* or *putreſcent* vegetables are qually powerful, in this reſpect, with the aceſcent; therefore, the antiſeptic quality muſt depend upon ſomewhat that is general, and common to all vegetables.*

INSTEAD

* By far the greateſt ſhare of the vegetables uſed in common diet, if we except the *fruits* and *farinacea*, are alcaleſcent or putreſcent; witneſs all the different kinds of *braſſica*, the *naſturtia*, *onions*, *leeks*, *garlick*, *horſe-radiſh*, *muſtard*, *radiſhes*, *ſpinage*, *endive*, *purſlain*, *lettuces*: not one of theſe things can be called aceſcent, and yet they preſerve

INSTEAD of calling *chyle* produced from a vegetable diet *acefcent*, we fhall fpeak with more propriety, as well as approach much nearer to the truth, by terming it a fluid compofed of animal and vegetable juices, in the *firft* or *fweet* ftage of *fermentation*, impregnated and fully charged with a fubtile, active, and penetrating fpirit, which is highly antifeptic.

THIS notion of *acefcent chyle* has fuch an influence on the practice of phyfic, that it is apt to prefent *acids alone* to the confideration of the phyfician, in *putrid cafes*, and too often diverts him from ordering thofe things which are the true oppofers and genuine correctors of putrefaction, namely, frefh vegetables, and other fermentable matters; fince *thefe*, upon comparing all the circumftances, will be found the *grand antifeptics*, that not only have the power to *preferve* animal fluids from corruption, but can alfo *reftore* them, after having undergone fome degree of putrefaction.

BUT what proves, almoft to a demonftration, the antifeptic power of the fermentable fubftances, is the cure of the *fea-fcurvy*. This difeafe, wherein

ferve the humours from putrefaction, or correct it when prefent, as effectually as forrel or lemon-juice. We fometimes find in fyftematic writers, laid down among the general caufes of the *putrefactive diathefis*, the too liberal ufe of fuch fort of vegetables; but I apprehend there are few, if any, inftances of a putrid difeafe arifing from the ufe of any found, fermentable vegetable.

Indeed, where people have been obliged to feed on fuch vegetables as were unfound, and incapable of the alimentary fermentation, there it will readily be granted, that the very worft of putrid difeafes have enfued.

wherein the whole maſs of fluids is diſſolved and corrupted, cannot be cured by any other means than by throwing in a large quantity of *new air*; * and this muſt be done in the way of diet; it muſt be furniſhed from things that can be taken into the body by pounds, not in ounces or drachms; and therefore that vegetable is found to be the moſt powerful antiſcorbutic of which the patient can take the largeſt quantity, without occaſioning ſickneſs, or other diſturbance.

IN the *ſcurvy*, the *digeſtive organs* luckily preſerve their full powers, and therefore they can turn the fermentable ſubſtances, taken into the body, to their own proper advantage; and hence this diſeaſe ſcarce ever fails of being cured, provided the requiſite materials be ſupplied.

BUT in *acute* diſeaſes, ariſing from putrefaction, the caſe is far otherwiſe; every thing, here, is thrown into ſuch confuſion, that none of the animal proceſſes can be carried on with regularity; and, on this account, the moſt powerful antiſeptics, as well as every thing elſe, too often loſe their power.

As

* With regard to practice, it is of no conſequence whether the antiſeptic power be aſcribed to air, or to the *volatile vegetable acid*; ſince it appears, that theſe *two*, are ſo *inſeparably* united, that when the *one* is diſengaged from any particular ſubſtance, the *other* muſt neceſſarily go along with it. The thing that is of real importance, is to point out thoſe medicines, and that kind of diet, which are capable of furniſhing the *antiſeptic ſpirit* in the greateſt abundance; and this, it is preſumed, has been ſufficiently done by the preceding Experiments.

As the cure of the ſcurvy, then, ſeems to depend ſo very much on the *fermentative quality* in the remedies made uſe of, it is not impoſſible but other things, as well as *perfectly freſh vegetables*, may be found to anſwer this ſalutary purpoſe.

I IMAGINE that I have found out ſuch a ſubſtance; I have had no opportunity, indeed, of putting it to the trial; but as I am firmly perſuaded that it will be found of great ſervice, not only in the *ſcurvy*, but in other *putrid diſeaſes*, at ſea, where freſh vegetables are not to be had, I cannot refrain from throwing out a propoſal for trying *new methods* of preventing, and poſſibly curing, thoſe deſtructive diſeaſes that take their riſe from putrefaction, in ſituations where the unhappy patients are deſtitute of the moſt proper means of help; but as this requires a particular conſideration, it ſhall be made the ſubject of another *Eſſay*.

HOWEVER, I will, in the mean time, recommend the trial of an experiment in that very deſtructive diſeaſe, the *putrid yellow fever* of the *Weſt-Indies*. And if theſe papers ſhall happen to fall into the hands of any practitioner in thoſe climates, I requeſt that it may be tried.

IT is, to give the patients repeated doſes of the *alcaline ſalts*, in freſh *lime juice*, or the like, and let it always be ſwallowed during the effervefcence; and let the patient's drink be ſomewhat of the highly fermentable kind; I would even propoſe the juice of the *green*

ſugar-cane,

ſugar-cane, diluted, and acidulated with ſome of the recent ſour juices. *

POSSIBLY, by throwing in ſuch a quantity of antiſeptic vapour as would be furniſhed from this kind of materials, the putrefactive acrimony, which at firſt ſeems chiefly to affect the biliary ſyſtem, might be corrected and ſaturated.

THE principle on which the ſaline mixtures, when given during the ebullition, perform their action of ſweetening and deſtroying the putrefactive acrimony, the reader can be no ſtranger to, or if he does not recollect it, he has only to turn back to the 23d, 24th, and 25th experiments of this preſent eſſay. †

* Mr. *Mornington*, ſurgeon to the 69th regiment, who was ſome time at *Goree*, on the coaſt of *Africa*, tells me, that the natives give in theſe fevers, with very good ſucceſs, a drink prepared by macerating in water a fruit of the plumb kind, that grows there in great plenty.

† Or, if the reader chuſes to have their action accounted for in another manner, I refer him to Dr. *Barry*'s Treatiſe on the three digeſtions, page 50, or to Dr. *Whytt*'s book on nervous diſorders, page 485.

ESSAY IV.

ON THE

SCURVY;

WITH A

PROPOSAL for trying NEW METHODS

TO

Prevent, or Cure, the ſame at Sea.

FOR ſome time, even before I engaged in the courſe of experiments which have been ſet forth in the three preceding eſſays, I was firmly of opinion, that the cure of the *ſea ſcurvy* depended chiefly, if not altogether, on the *fermentative quality** of the *freſh vegetables*; which are found,

by

* Although the ingenious Dr. *Lind* aſcribes ſomewhat to the fermentative quality, yet his theory reſts chiefly on the *ſaponaceous*, *attenuating*, and *reſolving virtue*, which, according to him, " is the chief, and moſt eſſentially re-" quiſite quality, in the antiſcorbutic mixture." P. 304 of his Treatiſe.

The theory, which makes the cure to depend on a change produced in the diſeaſed fluids, in conſequence of the fermentation of the freſh vegetables in the ſtomach and bowels, was firſt taught (as I am informed) by Dr. *Cullen*, but was ſuggeſted to me by Dr. *Hutcheſon*.

by experience, to be the only things that, with certainty, conquer this deſtructive diſeaſe. And in conſequence of this perſuaſion, it occurred to me, that as there are vegetable ſubſtances, which, though not perfectly recent, are yet capable of fermentation, ſuch in particular as *common malt*; that this, if taken in the way of medicine, would, in all probability, produce effects ſimilar to thoſe produced by green vegetables, and conſequently cure the ſcurvy; and as *malt* can be preſerved ſound, for a conſiderable length of time, it might be carried to ſea, and there kept, in order to make *wort* occaſionally as it might be wanted; and thus prove a remedy, always in readineſs, againſt that fatal diſeaſe.

Such was the ſcheme that I framed to myſelf; and the more I thought of it, the more I became convinced of the likelihood of its ſucceeding.

I soon mentioned this affair to a few of medical friends, who having formed themſelves into a little ſociety, meet once a fortnight for their mutual improvement; and they thought the reaſons on which my expectations were founded ſo plauſible as to deſerve the trouble of an experiment: So that all that was now wanting was an opportunity of putting it to the fair trial.

But as the *ſcurvy* * is a diſeaſe very rarely to be met in this city, and as I had not any acquaintance

* The genuine putrid ſcurvy, ſo fatal to ſeamen, and to people ſhut up in garriſons, without ſupplies of freſh vegetables, is the diſeaſe every where meant throughout this Eſſay.

quaintance at the places where cafes of this fort occur moft frequently, I drew up my reafons for thinking that the *wort* would prove a remedy, in the form of a letter, and addreffed it to my very worthy friend Mr. *George Clegborn*, lecturer of anatomy in the univerfity of *Dublin*, with a defire that he would fend it to fome of the leading medical people in *London*, in order to engage them in an application to the gentlemen who have the care of the naval hofpitals, that trial might be made of its effects at thofe places.

Among the gentlemen to whom Mr. *Clegborn* tranfmitted copies of the letter, were Dr. *Hunter*, and *Henry Tom*, Efq; one of the *commiffioners* for taking care of *fick* and *wounded feamen*, whofe zeal in the profecution of this affair, and in endeavouring to get the propofal carried into execution, demands a publick acknowledgement; fince it was through their application, that the *lords* of the *admiralty* did, in the month of May, 1762, give orders to have the *wort* tried in the naval hofpitals at Portfmouth and Plymouth.

But as it was abfolutely neceffary, in order to determine the genuine effects of the remedy propofed, that the patients fhould, during the time of trial, be entirely debarred from every fort of recent vegetable, this reftriction was deemed fo fevere, and looked fo like retarding men's cures for the fake of experiment, that it occafioned a general murmur and difguft,

guſt, and, of courſe, put a ſtop to the further exhibition of the *wort* at the hoſpitals. * Orders were then iſſued to have it given on ſhip-board, while at ſea, where no temptations of freſh vegetables would offer to make the men uneaſy, and where it was expected that the patients would chearfully ſubmit.

But hitherto, † no return has ever been made to the offices, either of the good or bad effects of the *wort*; whether this hath ariſen from diſobedience, or inattention, is not eaſy to determine; poſſibly, each may have had its ſhare; for, of all men, thoſe who uſe the ſea,

* I had the honour of a letter from Dr. *Huxham*, dated October the 13th, 1764; wherein he tells me, that the *wort* was tried both at *Plymouth* and *Portſmouth*, with *very bad effects*. He has not indeed ſpecified what theſe bad effects were; but it is eaſy to conceive, that the patients, when laid under the reſtraints above-mentioned, would *make* a variety of grievous *complaints*. However, I am perfectly well aſſured by a gentleman, who himſelf made uſe of the wort, that it may be taken, for a length of time, to the quantity of a quart in the day, without producing any ill effect whatever; and by looking into *Van Swieten*'s commentary, the 4th vol. p. 673, the reader will ſee that the *Baron*'s lady, when a nurſe, uſed regularly to drink a pint of it every night going to bed, in order to increaſe her milk.—See the appendix, No. 3 and 4.

† In a letter, dated 17th Feb. 1763, which I was favoured with from Commiſſioner *Tom*, I was told, that at that time none of the navy-ſurgeons had reported any thing concerning the Wort; but Mr. *Tom* engaged to acquaint me of the particulars, as ſoon as a return ſhould be made to the office.

But as I have never had the pleaſure of hearing from that gentleman ſince (it is now 23d June, 1766) I take it for granted that nothing has been done in conſequence of the admiralty's order, nor any report ever made.

ſea, are the moſt averſe from innovation and experiment.

But nevertheleſs, as I am now, in conſequence of thoſe experiments which have been already made known to the reader, more than ever convinced that the cure of *putrid* diſeaſes in general, and that of the *ſcurvy* in particular, depends greatly on the quantity of *new air* thrown into the blood from eaſily fermentable ſubſtances, I ſhould deem myſelf wanting in common humanity if I did not communicate this to the public, and make it my requeſt, that ſuch people as are concerned in long voyages may embrace ſome opportunity of giving the *wort* a fair trial; for until it is diſproved by actual experiment, I ſhall ſtill continue to think, that this liquor bids as fair to cure the *ſcurvy* as the juice of any recent vegetable. The experiment can occaſion no poſſible danger, will be attended with very little expence or pains, and, if it ſucceeds, will make ample amends, in producing a diſcovery of infinite advantage to the ſeafaring part of mankind.

If it be true what was publiſhed in December, 1762, taken, as is ſuppoſed, from returns made to the houſe of commons, that of *one hundred* and *eighty-five thouſand* men, raiſed for the ſea ſervice, during the late war, above an *hundred* and *thirty thouſand* periſhed by diſeaſes, and that two-thirds of this number may be ſafely charged to the account of diſeaſes which take their riſe from putrefaction;

tion; ſurely, every motive of policy and humanity ſhould excite men to endeavour at finding out ſomewhat to check this fatal and deſtructive *diatheſis*; for if ſeamen could be preſerved from it, few other kinds of diſeaſes would endanger them.

For a ſea-life, ſimply conſidered, is ſo far from being productive of diſeaſes, that it is found to be a remedy againſt ſome of the moſt dangerous kinds; * and though habitual intemperance, and incautiouſly expoſing themſelves to heat and cold, may, and frequently do, cut ſhort the lives of ſeamen, yet the great mortality to which the crews of the king's ſhips are too often ſubject, ariſeth from infectious diſeaſes, owing to ſuch numbers being crowded together, and living in circumſtances leſs cleanly than is uſual in the merchants ſervice, where the men breathe a purer air, and are in general cleaner, and better cloathed, though by no means better, nor perhaps ſo well, fed, as in the royal navy.

Whoever has read Dr. *Lind*'s excellent treatiſe on the *ſcurvy*, muſt be convinced that the *principal* and *main prediſpoſing cauſe* is *too great a degree* of *moiſture* in the *atmoſphere*, whether hot or cold, but more eſpecially the latter; and that the uſe of ſalt diet, bad water, or foul air, can only be reckoned as ſecondary cauſes, which will not of themſelves produce the diſeaſe.

The

* See *Gilchriſt*'s ingenious diſcourſe on the *uſe of Sea-Voyages in Medicine.*

The manner in which *excessive moisture* brings on the *putrefactive diathesis*, we have already attempted to explain; and have endeavoured to point out the most effectual methods of preserving the body from its ill effects.

It has been alleged, that this depends very much on keeping the surface of the body always warm and dry, by wearing enough of clean apparel to absorb the *aqueous* part of the perspirable matter; and, at the same time, making use of such diet as will supply a sufficient quantity of that principle, which is known, from experience, to correct the morbid disposition, or tendency to putrefaction.

But here a question naturally presents itself; where are the bulk of the crew, the poor common sailors and marines, to get such kind of diet; or how are they to be always kept clean, dry, and warm, who, for the most part, have not a second suit, but are obliged frequently to lie down in wet cloaths, and go to sleep in damp hammocks?

To this it may be answered, let the men in the *navy* be cloathed in the same regular, exact, and uniform manner as they are in the *army*; and let them be allowed, *while at sea*, a daily portion of *sugar*; and I will venture to promise, that, in a time of war, we shall annually save some thousands of very useful lives.

When thinking on this subject, I have often lamented, that it has never been attempted to cloath the seamen in this manner. Such

a ſcheme, as it would occaſion conſiderable changes in the preſent naval ſyſtem, could not be carried into execution without ſome difficulty; but if it were once eſtabliſhed, it would certainly be productive of great and ſolid advantages, for it would attach the men firmly to the ſervice, and prevent a great deal of deſertion, by infuſing more powerfully that *eſprit du corps*, which binds people ſo ſtrongly together; and it would without all manner of doubt, render the fleet much more healthy; for the greateſt ſhare of thoſe terrible *putrid* diſeaſes, that ſweep off ſuch multitudes of our ſeamen, take their firſt riſe from a want of neceſſary cloathing; a ſpecies of diſtreſs which numbers of people, as things are now ordered on board the king's ſhips, muſt often labour under.

THE great importance of neceſſary cloathing may be plainly ſeen, by obſerving what happens to the commiſſion, warrant, and petty officers, on board the fleet; together with ſuch of the common ſeamen as are careful and provident, and pride themſelves upon being always neat and well cloathed. Theſe people are ſcarce ever ſeized with *acute* putrid diſeaſes, excepting by mere infection, and they are very ſeldom known to become *ſcorbutick*, to any violent degree, unleſs the *general cauſe* (exceſſive moiſture) be of a remarkably long continuance.

Now, the diet of all this ſet of men (the commiſſion, and ſome of the warrant and

petty

petty officers excepted) * is precisely the same with the rest of the crew, being nothing better than the common ship's provisions; and many of the petty officers sleep in a part of the ship, where the air must be even more confined than it is where the common men sleep.

The only circumstances wherein the people of whom we have been speaking usually differ from the common run of the crew, are, that they are *well clad*, and, for the most part never want a little store of *sugar*.

It would lead me from my purpose to pursue this matter any further; but the importance of it is so obvious, that I most heartily wish that some person, whose rank in life would insure him the public attention, would take the hint, and offer a plan for the regular cloathing of the seamen in the royal navy; the time being now come when such a thing might easily be attempted: the naval establishment being brought so low, and the several commanders fixed to their ships, for at least some years, will give leisure and opportunity for trying if such a scheme can be carried into execution.

But altho' the cloathing scheme should never take place, yet the other part of the proposal may be easily adopted; and I sincerely wish

* If these gentlemen fare better than the rest of the crew, it must be all at their own expence; for the government provides nothing better for the officers than it does for the meanest person in the ship.

wish that *sugar* or *melasses* may hereafter be allowed, as a part of *sea provisions.*

The expence, even taken at the highest, is too trifling, when put in competition with preserving so valuable a part of the community as our seamen; but I am convinced, that the government would rather be gainers by affording the seamen this allowance; for the savings at the hospitals, which would not then be crowded in the manner they have often been, would more than pay for all the sugar expended *at sea.*

The reader must have already perceived the principle upon which it is proposed to cure the *scurvy* by the use of *fresh wort*; but as I do not imagine that any person will take the trouble of making the experiment, unless he is almost as fully persuaded as myself, I am under the necessity of entering into a farther explanation of the reasons which lead me to expect that this liquor will produce such salutary effects.

Notwithstanding the many impudent assertions every day published in the common news-papers, which, among other much-boasted remedies, promise not a few as peculiarly specific against the *scurvy*, * yet it may be

* If any of these *nostrums* be *spirituous tinctures*, the material from whence they are extracted, if it ever had any antiscorbutic virtue, must be deprived of it by this manner of treatment; and the tincture itself must be so far hurtful, as every kind of ardent spirit is found to be extremely pernicious in this disease.

If

be laid down as a poſition, not eaſily to be controverted, that the *genuine putrid ſcurvy* has never been known to yield to any other medicines than to ſuch as are compoſed of *freſh vegetables*;† and provided they be *freſh*, and of ſuch a nature as will allow them to be taken freely, it is almoſt no matter what they are. The *acid* and the *alcaleſcent*, the *mild* and the *acrid*, the *ſweet* and the *bitter*, all of them cure the *ſcurvy*; though their ſenſible qualities be ſo oppoſite, and their manner of affecting the body, in ordinary caſes, be ſo different.

THIS virtue, then, *muſt* be owing to ſome property which they *all* poſſeſs in *common*.

THE experiments of the three preceding eſſays will, as I apprehend, be allowed conclusive,

If they be *mineral acids*, they are ſufficiently known from experience to be uſeleſs, either as remedies or *prophylactics*.

But if they contain *mercury*, they muſt be as ſo much poiſon, for mercury breaks down the blood, and deſtroys its texture, in like manner with the ſcorbutic acrimony.

† The only places where I meet with any thing like a contradiction to the above aſſertion, are in *Biſſet*'s Account of the Scurvy, and in the Hiſtory of the Voyages made by the *Ruſſians* in order to diſcover the *American* coaſts oppoſite to *Kamtschatka*.

The firſt-mentioned author thinks that many people were cured at *Cumberland* harbour, in the iſland of *Cuba*, merely by feeding on *rice*, and before they were ſupplied with any recent vegetables. See p. 83 of his treatiſe.

And in the laſt-mentioned book, the cure is entirely aſcribed to eating the fleſh of the ſea-cow. But the authors do not take notice, that the ſame ſpring-ſeaſon, and warm weather, that induced theſe animals to ſeek the land, muſt alſo have thrown up a variety of vegetable productions, which the ſcorbutic patients would moſt greedily devour, without waiting for the doctor's directions

clusive, in shewing that a property, *common to all fresh vegetables*, is, that when mixed with any *animal* substance, and placed in the proper degree of heat, they presently run into *fermentation*, and, in the course of that fermentation, throw off a subtile *vapour*, or spirit, of surprising activity, endued with a power of *restoring sweetness* to *putrid* animal fluids.

This hath been so clearly and so abundantly proved already, that there cannot be the least necessity for repeating what hath been said of it in the three foregoing essays; I shall therefore only mention some circumstances with regard to the *cure* of the *scurvy*, which will afford almost a demonstration that it depends on the change brought about in the diseased fluids, by the action of the subtile, active, and penetrating spirit, which is generated during the fermentation of the fresh vegetables, carried on in the first passages.

First, the recovery of people in the very *last stages* of the *scurvy*, is brought about in a surprisingly short space of time, provided the patients are but fully supplied with *fresh* vegetables. This is sufficiently confirmed by every account of the scurvy that we meet with; and *John Woodall*, an old English surgeon,* who hath

* Although *Woodall* was a man of great eminence in his day, and of no inconsiderable merit as a writer, yet his book appears to be very little known. The only places where I see it mentioned, are in *Wiseman*'s preface, and in the preface to *Turner*'s surgery; but it is not to be found in *Haller*'s catalogue, neither in *Heister's Bibliotheca Chirurgica*; not,

had left us a very accurate deſcription of the diſeaſe, paints this ſalutary change in a very ſtriking manner, by ſaying, "That to any "man of judgment it may ſeeme a wonder, "how a poore miſerable man, coming on "lande from a long voyage, even at the point "of death, namely, ſwoine ſometimes to an "exceeding greatneſſe, not able to lift a legge "over a ſtraw, nor ſcarce to breathe, by "reaſon of ſtrong obſtruction, yet, in a *few* "*dayes*, ſhall receive the fulneſs of former "healthe, yea, with *little* or *no medicine* at "all."

SURELY this change muſt be wrought by ſomewhat of amazing activity, and does not depend on a *ſaponaceous*, *attenuating*, or *reſolving* virtue; for in the *ſcurvy* the "*craſis of* "*the blood is broken and deſtroyed by the ſcorbutick putrefaction*," and certainly *never* can be reſtored to a ſound ſtate, by being *further* attenuated and reſolved; neither have we ſufficient time, in theſe caſes, "*for* "*the*

nor, which is ſtill more to be wondered at, in *Lind's Bibliotheca Scorbutica*; notwithſtanding that *Woodall* hath left a very excellent diſcourſe on the ſcurvy, his deſcription of which appears to have been drawn from his own obſervation, and his method of cure founded on experience, for he ſerved both at ſea and in the army. For theſe reaſons, I am perſuaded that the reader will be pleaſed to ſee an extract from this part of his works, which conſiſt of ſeveral diſcourſes on medical, chemical, pharmaceutical, and chirurgical ſubjects, printed originally at different times, but all collected by himſelf, and re-publiſhed in a thin folio, in the year 1639, with a dedication to King Charles, under the title of *The Chirurgeon's Mate, or military and domeſticke Surgery.*

"*the putrefactive acrimony to be diluted, and* "*obtunded by the watery and mucilaginous* "*parts, and carried out of the body by the ape-* "*rient quality of the vegetable juices.*" Nor does the mechanical action of "*scouring and* "*cleansing the furred and obstructed passages of* "*the machine,*"* at all correspond or agree with the appearances that attend the progress of the cure; which is always found to depend on vegetables only so far as they are *fresh* and capable of yielding a large proportion of the *antiseptic spirit*; for although the dry *farinacea*, when mixed with the animal juices, ferment very readily, yet both reason and experiment shew, that they will not do it with so much ease, nor produce so much air, as the fresh succulent vegetables; therefore, notwithstanding that bread, without any other vegetable assistance, will serve, in ordinary cases, to raise the common and necessary alimentary fermentation, and produce enough of the antiseptic vapour to *preserve* the juices in a sound state; yet if a *putrid* acrimony hath once taken place in the constitution, the *crude* and *dry farinacea* are found quite insufficient to conquer it; and there is then an absolute necessity for throwing in a large quantity of *fresh vegetable juice*, not so much to obtund and sheath the putrefactive acrimony by its mucilaginous quality, as, by its *fermenting* in the bowels, to generate a sufficiency of the subtile spirit, which seems to be the only thing capa-

ble

* See *Lind on the Scurvy*, p. 304, 306.

ble of pervading, in ſo ſhort a time, the moſt intimate receſſes of the whole vaſcular ſyſtem, and of totally changing the corrupted nature of the entire maſs of fluids.

SECONDLY, the liquors which have completed their firſt ſtage of fermentation, and thereby loſt much of their *fixed air*, though they are found uſeful as preſervatives, will none of them *cure* the diſeaſe: Cyder, which appears to have a greater degree of antiſcorbutic virtue than any of the common fermented liquors, is generally ſtopped ſooner in its career of fermentation, and contains the more *fixed air* on that account. *

THIRDLY, *acids*, † both mineral and vegetable, and *ardent ſpirits*, ‡ which contain little *fixed air* in themſelves, and check the alimentary fermentation, are found to be, the firſt, uſeleſs and inſignificant, and the ſecond extremely hurtful, in the diſeaſe.

UPON the whole, then, it may ſafely be repeated, that the *cure* of the *ſcurvy* depends on the *fermentative quality* in the remedies made uſe of.

U AND

* See the note in page 115.

Cyder has been tried at ſea, on the recommendation of Dr. *Huxham*, and he tells me, in the letter mentioned in a former note, that it was uſed in the navy with great ſucceſs.

† "Experience has abundantly ſhewn, that they (*Sp. "Salis*, *Elix. Vitrioli*, and *Vinegar*) have not been ſuffi- "cient to prevent this diſeaſe, much leſs to cure it." *Lind*, p. 187.

‡ This is ſtrongly proved by the remarks of governor *Ellis*, in his account of the voyage to *Hudſon*'s *Bay*.

AND this being the cafe; we have only to find out a fubftance which may be preferved for fome confiderable length of time, and yet fhall contain materials for raifing a fermentation in the bowels like that raifed by frefh vegetables; and then, in all human probability, we fhall have a remedy for the *fcurvy* always in readinefs.

SUCH a vegetable fubftance, it is prefumed, is *common malt*.

GRAIN, after it is *malted*, differs widely from grain in the *crude ftate*; by the germination, drying, and flight torrefaction, its natural vifcidity is deftroyed, it acquires an agreeable faccharine tafte, and the farinaceous part is fo attenuated as to be rendered foluble in water.

FRESH *wort*, or *infufion* of *malt*, is a liquor fimilar to the recent juices of the fweet vegetables; fermenting readily like them, and being precifely of the fame mild, faponaceous, and aperient nature.

WHAT then fhould hinder it from producing the very fame effects? and, as it may be taken in as large a quantity, with as much fafety, and with as little difguft, there can be no reafonable objection to its being given. All that remains, then, is to put it to the fair trial; and this I certainly fhould have done, long ago, if an opportunity had ever prefented itfelf.

BUT the fame objections that were made at the naval hofpitals, muft always be made, as often as the experiment is attempted on fhore; therefore

therefore, whenever it ſhall be fairly tried, it muſt be at ſea.

Let me then again requeſt, that ſuch of my readers as may have opportunities, will try the effects of this liquor : * and this is a matter of ſuch importance, as to render it well worth the beſtowing of ſome expence and pains ; for if the *wort* ſhould be found to anſwer, it will undoubtedly be the means of ſaving the life of many a brave fellow.

For malt, as I am aſſured by the brewers, with proper care, may be preſerved ſound and good for years ; ſo that if it were previouſly well dried, packed up in ſmall caſks, and ſtowed in the bread-room, or ſome very dry part of the ſhip, it might be carried to ſea, and kept for any length of time that would be required, even in the longeſt voyages ; and as there need be no very large quantity carried, it would not incommode the ſhip by its bulk ; ſince I do not mean, that it ſhould be given as a part of the common diet, in the way of preſervative, but only to ſuch as are actually ſick ; when the *malt* is to be ground, and made occaſionally into *wort*, as it may happen to be wanted.

The method in which I would propoſe the *wort* ſhould be given, is, to boil it up into a *panada*, with the ſea-biſcuit, and ſome of the dried

* The *Eaſt-India Company* would do well to order ſome malt to be carried out in their ſhips, and give poſitive directions to have trial made of its effects, as there never fails to be abundance of opportunities during the courſe of theſe voyages.

dried fruits that are usually carried to sea; then let the scorbutic patients make at least two meals a-day on this palatable mess, and let them drink a quart, or more, if it shall be found to agree (always beginning, however, with a smaller dose, and gradually increasing it) of the *fresh infusion*, in the course of the twenty-four hours.

Its most likely effect will be to open the belly, a most agreeable circumstance to the poor scorbutics (in whom obstinate costiveness is a very common symptom) and exactly similar to the *modus operandi* of the most powerful *green antiscorbutics*.

But like them too, if taken too liberally, it may occasion gripings, and immoderate purging; when this happens, the dose must be lessened, and some drops of the *acid elixir of vitriol* may be given with it, in order to check the too great tendency to fermentation, and make it sit easy on the stomach.

And it is not only in the *scurvy*, but likewise in *acute* putrid diseases, that I expect the *wort* will be found of singular service. In all such where the putrefactive acrimony seems to be unaccompanied with any *peculiar pestilential taint*, it promiseth to produce very good effects, from the principles already laid down; for as most of these *simple putrid* diseases arise from an accumulation of sharp and corrupted matter, in the first passages, such medicines as will *dilute*, *obtund*, and above all *ferment*, and, in that action, produce a suffi-

ciency

ciency of the *antiseptic vapour* to saturate and sweeten the putrefactive *colluvies*, bid the fairest to give present relief.

In these cases, the *wort* may make a principal part of the sick person's diet; a thin panado for meat, and the plain infusion, acidulated with lemon or orange-juice, if to be had, if not, with spirit of vitriol, for the common drink.

And this will bring things as near as the circumstances and situation will allow, to the very succesful practice of the celebrated *De Haen*, at *Vienna*. In acute, continual, putrid fevers, his method is truly *Boerhaavian* and *simple*, consisting only in supplying the patients liberally with *oaten* or *barley* gruel, sweetened with honey, and made of different degrees of thickness, according as he intends it for meat or for drink; though, in some cases, they are indulged with flesh broth, made very light and thin. If the belly is not made soluble by the gruel alone, he occasionally mixes a little *cream* of *tartar*, or *nitre*: His medicines are all of the fresh fermentable kind; *flowers*, *leaves*, *succulent-roots*, and *ripe fruits*, made into decoctions, or infusions, according to the nature of the different materials: And his only cordials are decoctions of bread, made palatable by the addition of the more pleasant kinds of fruit, when in season, or, at other times, by the same, preserved, and made into jellies, syrups, or what is usually called *jam*; with now and then some small doses

doſes of the milder *antimonials*, or ſome of the *neutral ſalts*: Nor does he ever give his patients any of thoſe trifling and inſignificant mixtures which fill up the *German* diſpenſatories.

By theſe plain, ſimple, and pleaſant remedies, he finds the extraordinary ſickneſs and nauſea, which attend all theſe putrid fevers at the beginning, is preſently allayed; inſomuch, that he ſcarce ever thinks of giving an *emetic*. The tormenting thirſt is ſo effectually relieved, by theſe diluent, mild, and ſaponaceous drinks, that the patients very ſoon forget to complain of it; and by their power, likewiſe, the putrid acrimony which occaſioned the diſeaſe, is early obtunded and corrected, the diſturbed ſecretions are preſently reſtored to order, and the whole maſs of humours preſerved from corruption and diſſolution: Hence, patients with petechial and miliary eruptions, proceeding from a diſſolved ſtate of the fluids, are rarely to be ſeen in the hoſpital that *De Haen* has the care of; neither are his patients afflicted with violent vomiting or purging, the acrimonious matter being ſo early corrected, that even the appetite frequently returns, during the very courſe of the fever. *

DE HAEN, agreeably to the common theory, makes the virtue of all theſe things to depend on their producing *aceſcent chyle*; but how liable this way of accounting for it is to objections, the reader hath already been informed: It is on account of their *fermentative* quality,

* *De Haen, Ratio Medendi*, in capite 1° & 2°.

quantity, and on their producing much of the *antiſeptic vapour*, that all theſe things perform ſuch wonders; and if they actually do perform them, there is all the reaſon imaginable to expect that the *wort* will not come far ſhort. I do therefore again moſt earneſtly recommend a trial of it, in the *acute*, as well as in the *chronic*, putrid diſeaſes.*

Although I have all along inſiſted on the *wort*, as thinking it comes the neareſt to the *freſh* juices, in every reſpect, yet, where *malt* is not at hand, I would recommend that *melaſſes*, *honey*, or *ſugar*, † may be tried, diſſolved in

* In *Tiſſot*'s *Avis au Peuple*, the reader will meet with many inſtances of the good effects of freſh vegetables in putrid diſeaſes, particularly the dyſentery; a diſeaſe, which vulgar prejudice has often aſcribed to the eating of fruit:—One inſtance is ſo very ſtriking that I cannot forbear tranſcribing it.—In the year 1751, the putrid dyſentery made great havock in Switzerland, and in the ſouth of France. "The diſtemper having nearly deſtroyed a Swiſs regiment; the captains purchaſed the whole crop of ſeveral acres of vineyard; there they carried the ſick ſoldiers, and gathered the grapes for ſuch as could not bear being carried into the vineyard; thoſe who were well eating nothing elſe. After this not one more died, nor were any more ever attacked with the dyſentery." See p. 342 of the tranſlation, by Dr. *Kirkpatrick*.

† Dr. *Cullen*, who has very ſanguine *expectations* from the *wort*, thinks that *ſugar* bids fair to cure the *ſcurvy*, as well as the *wort*: And it certainly does ſo; for the ſame reaſons that lead us to expect that the one will prove a remedy, hold good, in almoſt every circumſtance, with regard to the other.

New ſpruce-beer is known to be a moſt powerful antiſcorbutic; but this virtue ſeems to depend chiefly on the melaſſes that is mixed therewith, in order to make it ferment;

in a due proportion of water (about four to one) and given in ſuch manner as may be found moſt agreeable and convenient to the patients.

The method in which it is propoſed to prepare the *wort*, is, to take *one* meaſure (ſuppoſe a quart) of the *ground malt*, and pour on it *three* meaſures of boiling water; ſtir them well, and let the mixture ſtand, cloſe covered up, for three or four hours; after which, ſtrain off the liquor.

It muſt be brewed, in hot weather eſpecially, freſh every day; for if it be allowed to grow vapid, or ſouriſh, it will not only be unpleaſant, but uſeleſs, as it would not then run eaſily into fermentation; but when perfectly freſh, there cannot well be a more palatable kind of drink, and I dare ſay, that, in general, it will ſit light and eaſy on the ſtomach.

If what hath been urged ſhall be found of ſufficient weight to engage any gentleman in a trial of the *wort*, all that I have further to requeſt, is, that he will, previous to its adminiſtration, carefully and particularly note down

ment; for I apprehend that a decoction of *dried* fir-tops, alone, would no more cure the *ſcurvy*, than the decoction of any other dried vegetable, great variety of which have been tried, but always without ſucceſs. See the appendix, No. 5.

Honey, on the ſame principle, muſt be a good antiſcorbutic, and, as ſuch, may be recommended to officers, and others who can carry it conveniently, to eat ſome daily, which would, in all probability, keep off the extreme coſtiveneſs to which people at ſea are ſo very liable.

down the cases in which it is given; describing with accuracy the several symptoms, and relating fairly, and with candour, the progress and effects, from time to time, and let these observations be communicated, either to the public at once, or to the author at *Dublin.*

APPENDIX.

No I.

AN

EXTRACT from that Part of WOODALL's WORK which treats of the SCURVY.

HE prefaceth his discourse on the scurvy with lamenting, "That none of "his countrymen had, out of their "experience, taken in hand sincerely "to set down to posteritie the true causes, "signes, and cure thereof; neither left any "caveats, instructions, or experiences, for "the prevention or cure of the same." He therefore declares his intention "of informing the chirurgeon how he should demean "himself, to comfort his patient at sea, in "that most dangerous disease;" which, he tells his reader, "is a disease of the spleene, "whereby it is sometimes wholly stopped, "and sometimes only distempered."

HAVING bestowed a paragraph or two on the different names of the disease, he goes on to treat of the causes, signs, and method of cure, expressing himself in the following terms.

"THE causes are so infinite and unsearchable, as they far exceede my capacity to find them out: Some men conceive this disease happeneth unto seamen only through their being long at sea without touching at land, as at their coming on land, they presently grow strong again, and are, by the very fresh aire, and fresh food, cured, without much other helpe. The chief cause thereof is the continuance of salt diet, which is not to be avoyded at sea, want of sufficient nourishment, and of sweete water; and also for want of *aqua vitæ*, wine, beer, or other good water, to comfort and warme their stomachs withall.

"ANOTHER cause of this disease, to the ordinarie sorte of poore men, is want of fresh *apparel* to shift them with; which, indeed, among poore sailors, especially a sorte of them that are carelesss and lazie of disposition, is too frequent; partly also by not keeping their apparel *sweet* and *dry*, and the not cleansing and keeping their cabins sweet; this also ingendreth and increaseth the infection. Some charge bisket as a cause of the scurvy, but I am not of their opinion; some say, inordinate watchings are the cause thereof; some say, extreme labour, wanting due nourishment; some also affirm cares and grief to be the cause thereof; others affirm, the very heat of the aire, resolving the spirits. But what shall I amplify farther?

"for

"for it is alſo true, that they which have all "the helpes that can be had for money, and "take as much care as men can deviſe, are, "even by the *evil diſpoſition* of the *aire*, and "the courſe of nature, ſtrooke with a *ſcurvie*, "yea, and die thereof, at ſea and land "both. *

"THE ſignes of the ſcurvie are many; as, "namely, a general lazineſs and evil diſpo-"ſition of all the faculties and parts of the "bodie, ſaving the ſtomach and appetite, "which oftentimes is greater than ordinarie, "with them, for a long time.

"A DISCOLOURING of the ſkin, as if it "were fouler than ordinarie, with ſpots "darker coloured than the reſt, and ſome-"times alſo darkiſh blew ſpots.

"A FEVER at ſea commonly ends in the "ſcurvy; wherefore, beware of too large "bleeding, which oft increaſeth the griefe "and maketh it incurable.

"ALSO itching, and aching of the limbs, "are ſignes of the diſeaſe.

"SOMETIMES, alſo, the legges falling a-"way and drying, and the calves of the "legges

* In the beginning of the year 1760, "an unuſual, epi-"demic, and real ſcurvy prevailed over the county of "Southampton. Its influence extended itſelf ſurpriſingly "to the ſhips at Spithead, and to ſuch as were hovering "on the coaſt. It attacked ſome hundreds of the French "priſoners both in Wincheſter and Porcheſter caſtles; nor "were families living at their eaſe in the country exempted "from a ſlight attack; nay ſome few perſons were af-"flicted with it in a high degree." See *Lind*'s papers on fevers and infection, p. 28.

"legges growing hard and dry; as alſo immoderate ſwellings of the legges.

"Also the legges and thighes diſcoloured into frekells or ſpots, of a dirty, brown, ſad colour, much like the colour of a gangrenated or mortified member.

"Stinking of the breath, greate obſtructions of the liver, or spleene, or both; and, in the exerciſe of their bodies, their limbs and their ſpirit failing them.

"Shortnesse and difficultie of breathing, eſpecially when they move themſelves, but lying ſtill, find little griefe or pain.

"Their eyes of a leady colour, or like dark violets.

"Great ſwelling of the face, legges, and all over the body; paleneſs, or a foul pale colour in the face; ſwellings in the gums, rottenneſſe of the ſame, with the iſſuing of much filthy blood, and other ſtinking corruption thence; looſeneſſe of the teeth: Alſo ſome are troubled with extreme coſtiveneſs, that, for fourteen days together, they go not to ſtoole once; alſo many have ſtoppings of the urine, or, at the leaſt, making leſs water in two days than the partie drinketh in one.

"A coldnesse and ſtiffneſs of the ſinewey parts chiefly of the legges; ſome alſo have their muſcles, yea, and the ſinews of their thighes, arms, and legges, ſo waſted away, that there ſeemeth to be left only the ſkin covering the bones.

"Also

"ALSO it is manifest, that diverse of
" those which have been opened after death,
" have had their livers utterly rotted, others
" have had their livers swolne to an exceeding
" greatnesse; some, the spleene extreamly
" swolne; others have been full of water;
" others have had the lungs putrified, and
" stunk whilst they have lived.

" THESE and diverse other signes, too many
" for to be mentioned here, do afflict poor
" seamen, which are often past man's helpe,
" in such time and place as they happen; the
" cure whereof only resteth in the hands of
" the almightie."

AFTER mentioning *Ectbius* and *Vierius* as writers on the disease, and taking notice of the indications of cure as laid down by them, he says, " he may spare his labour, in writing
" what broths or herbes can serve best, where
" no freshe food can be gotten." He therefore goes on to direct the use of such things, as are usually carried to sea; namely, " wine,
" sugar, spices, and other comfortable things,
" which the chirurgeon ought to take care
" that the men have in due season; and,
" moreover, he ought, morning and evening,
" to seeke for poore and weake men in
" their cabins, or, so soone as they are missing
" at their messes, to enquire for them,
" and see that their cabins be sweet, and their
" provisions according.

" AND whereas the first part of this cure is
" in opening obstructions, it is therefore fit,

" In

"in the beginning of the griefe, to give an
"opening clyster; then the next day, if the
"party be strong, open a veine; but beware,
"as is said, of taken away too much blood
"at once."

If the disease be attended with swelling and fullness, he advises a purge, and then orders to make the patient some comfortable spoon-meat, namely, "an oatmeal caudle, with a "little beer or wine, the yoke of an egge, "and some *sugar*; or a broth, made with "currants or other fruite, with spices and *su*-"*gar*; and, for drink, barley water, with "some juice of lemons, if it may be had, if "not, with oyle of vitriol and *sugar*.

"The juice of lemons is a precious medi-"cine, and well tried, being found and good; "let it have the chief place, for it will well "deserve it. It is to be taken twice a-day, "a spoonful or two with *sugar*." In want of it, or the juice of *limes*, oranges, or citrion, or the pulp of tamarinds, give "oyle of "vitriol, as many drops as will make a cup "of beer or water sower a little, as it were, "and add *sugar*, or some syrup: A decoc-"tion of bisket, and therein almonds ground, "with sugar, and a little cinnamon or rose-"water is a very comfortable drink to be "taken now and then to refresh the stomach."

He proceeds then to give directions how to sweat the patients, and how to relieve extreme costiveness; next, he directs lotions for the rotten gums, and orders the swelled limbs

to

to be fomented with a weak lixivium, boiled up with ſome of the diſcutient and warmer kinds of herbs, and afterwards to be rubbed with particular ointments that he mentions.

In the cure of ſcorbutic ulcers, he remarks, that "until the obſtructions in the liver and "ſpleene, be removed, theſe ulcers give no "place to good healing;" and therefore adviſes "all ſharp and violent medicines to be "ſhunned, and nothing but ſoft and anodyne things to be applied, for otherwiſe, "you will not only ſtrive againſt the ſtreame, "but put your patient to needleſs diſquiet, "and thereby increaſe his diſeaſe.

"A poultice of biſket, boiled up in "beere or wine, applied warm, will won"derfully comfort a weak limb, and aſſwage "pain: But fattie things muſt be forborne "in ſome caſes; namely, when the pain is "ſharp and quick, leſt you cauſe putrefaction "and ſuppuration of the humours againſt "your will; yea, and rather uſe acetous me"dicines and anodynes."

This extract ſhews that *Woodall* was a man of ſome obſervation.

There are many good things for the time he wrote in other parts of his book; his method of treating wounds, both common and gun-ſhot, was judicious and ſimple; his dreſſings being, for the moſt part, very plain, chiefly dry lint, and he condemns the uſe of tents and eſcharotic applications.

With regard to fractures, he was an enemy to long rollers, or tight bandages.

When he amputated, he often made uſe of the croſs-ſtitch, to keep down the fleſh over the end of the ſtump; and he knew how to reſtrain the bleeding, by tying the veſſels.

He was the inventor of the *trefine*, which he ſo named from its three extremities *(a tribus finibus)* each ſerving a different purpoſe; and he was the firſt man who introduced the *enemata fumoſa*; * propoſing alſo to throw up, in this manner, powders, and the like, into the inteſtines, in order to cure obſtinate fluxes, and other diſeaſes of thoſe parts.

N° II.

Notwithstanding the haſty condemnation of the *wort* at the naval hoſpitals, I cannot help ſtill entertaining a favourable opinion of it, as a remedy againſt the ſcurvy and other putrid diſeaſes; and in order to ſhew that my expectations are not ill founded, I take the liberty to publiſh an extract of a letter which Sir *John Pringle* was pleaſed to favour me with, ſoon after the publication of the firſt edition; it is dated 14th May, 1764.

"Some

* It may not be amiſs in this place to inform the reader, that I have found, upon trial, that *tobacco-ſmoke*, thrown up in the way of clyſter, effectually and immediately deſtroys the *aſcarides*. And this I was induced to try upon the recommendation of Mr. *Turner*, ſurgeon at *Liverpoole*. See his letter to Dr. *Fothergill*, in the ſecond volume of the *Loudon Medical Obſervations*.

" Some time ago a paper of your's was " put into my hands, relating to the uſe that " might be made of malt in the cure of the " ſea ſcurvy; I was confirmed in the ſame " notion, by finding that unfermentable acids " were not the thing, and that a ſhip's crew " never ſuffered by that diſtemper in any " great degree, ſo long as they were plentifully " ſupplied with wine, ſmall beer, or other li- " quors, which had not undergone a complete " fermentation. During the late war, cap- " tain *Campbell* (who had made the long " voyage with lord *Anſon*) then commanding " the *Eſſex*, told me, that once upon a long " cruize ſeveral of his men had fallen ill of the " ſcurvy, and that he had cured them all on " board, by taking the diſeaſe early, and feed- " ing the ſick chiefly on a ſcotch diſh, called " ſooins, to which he added ſome wine and " ſugar. Captain *Campbell* was led to this pure- " ly from the notion of ſooins being a cooling " and light ſort of food; but at that time I at- " tributed the virtue to a mild acidity, produced " by a begun fermentation. According to " your principle, the ſalutary effect of this " meſs muſt be aſcribed to the factitious air, " put into a way of being eaſily diſengaged " from the oatmeal of which the ſooins are " made.

" A large quantity of water is added to " the meal, and put into a wooden veſſel in a " warm place; the fermentation is allowed to " go on for about forty-eight hours, then the

"water is poured off, and evaporated on the "fire to the confiftence of flummery, from "which the fooins only differ in becoming aci-"dulous by the fermentation. Captain *Camp-"bell* obferved, that the fermentation never "fucceeded fo well as when it was performed "in a wooden veffel, which was agreeable to "my experiments, and, I do not doubt, but "it proceeded the better from the water's "being fomewhat putrid.

"WHAT comes ftill nearer to your pur-"pofe, is an obfervation that I had this laft "winter from Dr. *Mounfey*, on his return from "*Ruffia*. He faid, that all the common peo-"ple there, and efpecially the failors and fol-"diers, ufe a liquor which they call *quafs*, "and which they reckon very falutary, and, "in particular, good againft the putrid fcurvy, "to which they are greatly fubject.

"The *quafs* is a dough compounded of *malt* "and *rye-meal*, which they bake in ovens, "and then infufe in water, till a fermentation "begins, and continues about twenty-four "hours. This liquor, he fays, is then drunk, "is acidulous, and not unpleafant. Dr. *Moun-"fey* told me further, that upon reading my "book on the difeafes of the army, being "then at *Mofcow*, he had inquired at all the "jails in that city, as he afterwards did at "*Peterfburgh*, but could not find that the "diftemper, which I call the jail or hofpital "fever, was ever known in thefe prifons, al-"though they were generally pretty full, and

"not

"not more cleanly, than in other places: "This immunity from that fatal disease, the "doctor attributes in part to the greater use "of vegetables, to the eating of *rye-bread*, "and to the *quass*, which those unhappy "people have supplied to them in great "abundance."

N° III.

THAT wort may be taken with the greatest safety, and that it is not apt to produce any *bad effect* whatever, will appear sufficiently from the following letter; which, at the same time, shews how much may be done with respect to warding off the scurvy, by the dint of mere resolution.

I RECEIVED it from captain *Bray*, a commander in the royal navy; he had been desired to make use of the wort by a brother officer, who also wrote to me for further directions for his friend, but with such an imperfect account of the case, that I imagined there might be a complication of gout or dropsy, and therefore desired to have a particular history of it from the captain himself.

SIR, DEAL, June 18th, 1764.

"I RECEIVED your obliging letter of the "9th instant; am perswaded that my com-"plaint is an inveterate scurvy, which, I ap-"prehend, you will readily agree to, when "you have read the following account that "I shall give you:

"SINCE

"SINCE my firſt going to ſea, is now thirty-three years, and the firſt attack that I had of this diſorder was in the year 1741, after being reduced very weak and low, by a fit of illneſs off *Cadiz*. Before I could recover my ſtrength, I was attacked in ſuch a manner as almoſt to confine me to my bed, my legs ſwelling to that degree, that I was obliged to borrow ſtockings, my own being too ſmall. Notwithſtanding the condition that I was in, kept conſtantly walking the greateſt part of the day. I was at that time acting lieutenant of the *Saliſbury*; and the fleet, under admiral *Haddock*, coming down from *Mahon*, doctor *Lidderdale*, who was phyſician to the fleet, being an acquaintance of mine, I ſent for him; he adviſed me to go to *Gibraltar* by the firſt ſhip, telling me, that it was impoſſible for me to recover at ſea; but like all young people, I would not liſten to it, and was determined not to go in. Being juſt ſuperceded by the admiral, and had his promiſe of being made into the third vacancy that ſhould happen, which promiſe made me determine, if I was alive, not to be out of the way. My good friend viſited me often, and, by his good preſcriptions, and the indefatigable pains I took in walking, in about two months, altho' at ſea, I was ſo well recovered as to go on board the admiral's ſhip, and continued three months at ſea in her before we returned to *Gibraltar*.

"tor. Dr. *Lidderdale* has often said, that I
"was the only instance that he ever saw re-
"cover at sea, from so bad a condition.

"The next attack was in the river *St. Lawrence*, after the reduction of *Louisbourg*. "We wintered at *Halifax*, where we were "bound fast in ice till *April*; and having "very few vegetables off *Louisbourg*, and but "seldom on shore, till we were in the possession, I began to find my legs heat and "itch, had recourse to a flesh-brush, and "constantly had them rubbed three or four "times a-day, by which I thought to have "received benefit; but tho' I kept constantly "to it, while we were in the river *St. Lawrence*, I found it gain on me, as we here "had no vegetables, and this the second year "that we had in a manner been without, I "did not so much wonder at it. At my return from *Quebec*, had leave to be absent "from the ship while she was refitting, which "was about six weeks; then returned to the "ship, and sailed from *Spithead* in *February*, "and continued at sea in the bay until the "beginning of *August*, when I was ordered "into *Plymouth*; at which time my legs begun to swell, and I was so bad that, if we "had continued but one fortnight longer at "sea, I should not have been able to have "got from my cabbin to the quarter-deck "without help; and when I got on shore, "could not walk a quarter of a mile, without resting three or four times. When I

" was in the river *St. Lawrence*, I had fre-
" quent attacks, with violent pains in my ſto-
" mach, which uſed to laſt about twelve
" hours, and then go off; was obliged,
" when taken with it, immediately to go to
" bed, ſo ſoon as I had worked off an emetic.

" I HAVE never had the leaſt ſymptom of
" the gout or dropſy, have ever had a good
" ſhare of health, am very fond of all kinds
" of vegetables, and make great uſe of them.
" I have made uſe of the wort about ſixteen
" days, and find that the itching is greatly
" abated; but the directions that captain
" *Mc. Bride* told me, is not exactly as you
" mention, only making uſe of half a pint of
" malt to a quart of water. It no ways diſ-
" agrees with me, nor can I ſay that it purges
" me, yet I find myſelf ſomewhat eaſier than
" before I took it. I drink the quart in the
" twenty-four hours, and the greateſt part of
" it faſting. I was broke out before I begun
" the wort, but much more ſince; it is out
" ſomewhat like a ſurfeit, itches, are very
" ſore, ſtand up above the ſkin, and die away
" with a ſcruf, leaving a mark behind as af-
" ter the ſmall-pox, firſt red, and then turn
" brown, and never after alter the colour. I
" am going over to *France*, for about three
" weeks, to ſee my ſon; and, as ſoon as I
" return, ſhall begin and follow the direc-
" tions you have been ſo kind as to ſend me,
" for which I return you many thanks; and
" if, at any time, it ſhould be in my power

" to

"to return the obligation, you may freely
"command me.

"I AM afraid I have tired your patience with
"this long detail, and am, with respect,

SIR,

Your most obliged,

And most obedient servant,

JOHN BRAY."

N° IV.

THE passage in *Van Swieten*, referred to in the note, page 174, is as follows: "*Ætius* "dum lac deficeret in Nutrice, *Zythum* propi- "nari jussit; dixitque: *Eodem die Ubera lacte* "*replebuntur. Mulieri autem videbitur, ubi* "*poculum acceperit, omnibus membris langues-* "*cere & exsolvi, donec lac in Mamillis collec-* "*tum fuerit*. Debet autem talis cerevisia me- "racior nondum per fermentationem temu- "lentam vim acquisivisse; tunc enim forti- "ter inebriat. In pluribius lactantibus egre- "grium talis cerevisiæ effectum vidi; & qui "dem in propria uxore; quæ, dum infanti- "bus suis daret ubera, lectum petens, hujus "cerevisiæ libram sumsit, hoc cum effectu, "ut tota nocte ubera lacte plena haberet."

N° V.

THE following is taken from the *London* Magazine for *September*, 1764; I thought it

 very

very well worth the preſerving, and have inſerted it here, to the end that people may be inſtructed in the method of preparing a remedy for the ſcurvy, which may be conveniently carried to ſea, and is known, from repeated experience, to be very powerful in its effects.

To the AUTHOR *of the* London Magazine.

SIR,

' I CANNOT refrain from communicating,
' through your uſeful magazine, to the pub-
' lic, the experiences of a worthy friend lately
' deceaſed, Mr. *Peter Kinwood*, of *Topſham*,
' in *Devonſhire* (who had been many years
' in the ſea ſervice, and continued to his death
' to be concerned in ſhipping) in regard of
' the utility of a cheap and eaſily prepared
' drink, called by him *Chowder-Beer*, for pre-
' venting the ſcurvy in long voyages, or for
' the cure of it where it may have been con-
' tracted. Perhaps the term of *Chowder-Beer*
' may be a provincial phraſe, known only in
' *Devonſhire*: But the following inſtructions
' for brewing a drink of black ſpruce fir,
' with melaſſes, will explain the thing to every
' one's underſtanding; as I hope the account
' given of its utility will introduce it to general
' knowledge and uſe. The following account
' I give you verbatim, as tranſmitted to me by
' my friend; who, in all his actions, was ani-
' mated by a prevailing love and deſire to im-

' prove

'prove every talent committed to him, for the
'most extensive benefit of mankind. I am,

SIR,

LONDON, Sept. 13, 1764.

Your very humble servant,

A MERCHANT.'

'DRY spruce, if boiled in water about one 'hour and half, will make good *Chowder-Beer*. I think it the wholesomest drink that 'is made; I am seldom without it when 'I can get spruce. When I lived in *New-England*, I had a vessel that went from thence 'to the *West-Indies*, and the bay of *Honduras*, 'for logwood: I always charged the master 'of her to take black spruce with him, and 'give his men beer all the voyage, which he 'did, and his men were healthy and well in 'the *West-Indies* and in the Bay, when others, 'at the same time and places, that drank wa-'ter, were very sickly. I have so great an 'opinion of the beer, that I wish it was used 'in all our ships on the coast of *Guinea*, and 'in the *West-Indies*; and where at many 'places the water is very bad, which if brewed 'into this beer, by the fermentation, would 'likely make it good drink, and with the help 'of the spruce nothing so easy to make. I sup-'pose in the hot countries they need not boil, 'but about one-third, or a quarter part of the 'water, but enough to mix with the cold wa-'ter so as to warm it fit for fermentation: It

'fines, and is fit to uſe very ſoon. The
'ſpruce may be kept in any dry place good,
'for two or three years after cut. In the
'*Weſt-Indies* the melaſſes is plenty, ſo that
'the beer would coſt but a trifle. I heartily
'wiſh that encouragement was given for plant-
'ing theſe black ſpruce trees: I think it is the
'beſt wood of all the fir kind, very good for
'ſhips topmaſts, and other ſervice in ſhips.
''Tis a fine beautiful ever-green tree with a
'fine top: They grow in poor land, that at
'many places has little depth of ſoil; at *New-*
'*foundland* and in *New England*, a hard rocky
'bottom, that the roots go but little under the
'earth or moſs, ſo that knees are often made
'of one part of the root, and the other of the
'ſtock or body of the tree, and are put into
'ſhips built at *Newfoundland*; I have ſeen
'them uſed in ſhips here alſo: The ſpruce
'trees in the woods commonly grow near to-
'gether, and run up 25 to 30 feet long, with-
'out any conſiderable knots. The *Scots* firs
'that I have ſeen here are ſmall, and the tim-
'ber grows in a circle round the trees, ſo that
'they are apt to break off there. The black
'ſpruce is a very tough durable wood. If
'ſpruce beer was generally made uſe of in the
'*Weſt-Indies*, thoſe ſhips that go there from
'*Newfoundland* and *New England* would like-
'ly carry what ſpruce they could with them
'if they found a ſale for it: And for after
'ages it may be had in any part of *Britain*, if
'care is taken to propagate it, which I hum-
'bly

'bly presume would be of great service to the 'poor sailors and others. The kettles that 'ships have for their service, would do to brew 'for most common merchant ships, as in hot 'countries they need only to boil a small part 'of the water, but fill the cask mostly with 'cold water. It would be well some better 'kettles were found than copper, as at times 'boiling salt victuals in them they are nasty, 'and I fear hurtful in boiling clear peas for 'the men; green poisonous matter hanging 'about them. The sea cooks are not cleanly, 'and in stormy weather it is a troublesome 'office: If some thin iron kettles could be 'made, it might be much better.

'I MAKE no doubt it may be carried to the '*East-Indies*, and used there to good effect, 'as a preserver of health. Before the use of 'this beer was found at *Newfoundland*, the 'men were sickly, scorbutick, &c. but now no 'country where they are more healthy. I have 'heard a gentleman say, that now, when it 'has happened they had not the *Chowder-Beer*, 'for want of melasses, to drink, they would 'be sick. I cannot but think it must be very 'beneficial to the sailors in general, who after 'they leave this country, likely the beer they 'carry from hence is expended in six weeks 'or two months: After that, if their voyage 'is twelve months or more, water is their 'common drink, which if good it might be 'tolerable; but at many places it is very bad, 'and at times, at sea, stinks much in the

'casks.

'casks. The beer that is carried to sea from 'hence seldom is racked, so that by the motion 'of the ships, after it is a little time in draught, 'it is very indifferent drink.

'I HAVE been told by a gentleman that has 'put fir seed into the ground, that great care 'must be taken to cover it with a net, or some 'other thing, else the birds would eat it as 'soon as it appears out of the ground.

'IF spruce beer should be used in the mer-'chants service, and found to be salutary, no 'doubt they would also use it in the navy. It 'is a fine thing that the black spruce should, 'after so many years being cut, retain that 'good quality in it of making good *Chowder-'Beer*; here are some persons that have lived 'in *Newfoundland*, and know the service it is 'to people in drinking it.

The Method of Preparation of Chowder-Beer.

'TAKE twelve gallons of water, and put 'therein three pounds and an half of black 'spruce. Boil it for three hours; then take 'out the fir, and put to the liquor seven 'pounds of melasses, and just boil it up. 'Then take it off, strain it through a sieve, 'and, when milk warm, put to it about four 'spoonfuls of yeast to work it.

'FOR common drink for seamen two gal-'lons of melasses may be sufficient to an hogs-'head of liquor. It soon works. In two 'or three days stop the bung in the cask, and

'in

'in five or six days, when fine, bottle it for 'drinking.

'WHERE the spruce is green and plenty, 'they boil it but about three-quarters of an 'hour, so as that the bark will strip off from 'the branches by drawing through the hand. 'They never strain the spruce, but fill the 'cask, one-half or two-thirds full of cold wa-'ter, on about a pint or more of the grounds 'of the *Chowder* drank out of the cask. After 'taking the spruce out of the kettle without 'straining it, put the melasses into the kettle: 'Make it just boil up, and fill it into the cask; 'and the grounds of the *Chowder* left in before 'will soon work it. If the hot water will not 'fill the cask, fill it up with cold. No need 'of coolers to cool the liquor as in other beer. 'It drinks as well when one-half or two-thirds 'of the water is cold, as when you boil more 'of it. In the *West-Indies* they need boil 'but a trifle of the water; just enough to get 'the bitter out of the spruce. And two and an 'half gallons of melasses will make a hogs-'head of tolerable good drink. Good *West-'India* melasses make better drink than trea-'cle or coarse sugar: Though in the want of 'the former either of the others may serve.'

N° VI.

I FIND from Dr. *Nathaniel Hulme*'s dissert: *inaug: de scorbuto*, that the *cortex*, joined to the acid juices, has been used at sea with great success.

Mr

Mr. *Hodgkin*, a ſurgeon in the royal navy, was the firſt who introduced this practice: The method is to give a drachm of the cortex in powder, with an ounce of lemon or orange juice, three times a day; and night and morning the ſwelled limbs are to be bathed in vinegar. This courſe is to be perſiſted in, until the ſcorbutick ſymptoms diſappear: the belly all the while being kept open by gentle laxatives.

Dr. *Hulme* (who was alſo a navy ſurgeon) ſays, that he ſometimes found the cortex *in powder* to diſagree with the patients, by creating a great difficulty of breathing: in ſuch caſes he uſed a tincture inſtead of the powder, and then found that this uneaſineſs did not ſucceed. The tincture was made by digeſting two ounces and a half of the cortex, and half an ounce of myrrh, in a pint of brandy. Half an ounce of this, mixed with an ounce of the acid juice, was the uſual doſe.

ESSAY

ESSAY V.

ON THE DISSOLVENT POWER OF QUICK-LIME.

There are agents in nature able to make the particles of bodies ſtick together by very ſtrong attractions; and it is the buſineſs of experimental philoſophy to find them out. NEWTON.

THE experiments of the ſecond and third eſſays have ſufficiently ſhewn, that the coheſion of animal and vegetable ſubſtances depends *immediately* on the preſence of the *fixed air*; but how far the influence of this principle extends into the mineral kingdom, is not yet certainly known.

HALLER ſeems to think that it is very general, being here alſo the *vinculum*, or *gluten verum moleculis terreis adunandis*; * though it does not appear that he has any actual experiment of his own to confirm this hypotheſis.

A a But

* *Prim. Lin.* ſect. 244.

BUT ſince the publication of Dr. *Black*'s moſt ingenious paper on the *magneſia*, we cannot help being convinced that the theory holds good, at leaſt with regard to the claſs of bodies which he hath examined; to wit, the calcareous earths.

THE reader may remember, that the doctor's theory of calcareous earths is, that theſe bodies have a very ſtrong degree of affinity * with fixed air, and, in a natural ſtate, are replete with it; that by calcination they are deprived of this element, and hence become cauſtic and ſoluble in water; but that, upon reſtoring the fixed air, they are again rendered mild and inſoluble.

ALL this is very ſatisfactorily ſhewn in the eſſay above-mentioned; but it occurred to me, that it might poſſibly be ſtill further proved, and that in a way which would afford an ocular demonſtration. I thought that perhaps the diſſolved quick-lime might be rendered viſible, and would precipitate on transfering *fixed air* into *lime-water*. †

EXPE-

* And fixed air has a ſtronger affinity with calcareous earth than with any other ſubſtance yet known.

† In the manner deſcribed in the ſecond eſſay.

When I found that by transferring air into different bodies, a variety of curious changes were produced, I laid aſide the glaſs tube, and had an apparatus prepared which rendered the performance of the experiments more eaſy. I cauſed a metal tube to be fixed on by a ſcrew to the neck of a phial, as repreſented in fig. IV. which tube could be occaſionally inſerted into the mouth of another phial, being previouſly

EXPERIMENT I.

I PRESENTLY ſet about the experiment, and found it anſwer fully to my expectations; for the lime-water, which was filtered, and perfectly limpid, became turbid in a few minutes after the efferveſcence began, and that the air which was extricated from the mixture of acid and alcali, had paſſed over into the phial containing it. And it was highly pleaſing to ſee the particles of the quick-lime, which, but two or three minutes before, were quite inviſible, and diſſolved in the water, all running together, and falling to the bottom, having returned to their original ſtate of inſolubility, the moment they were ſaturated with the fixed air.

WHEN the turbid mixture had ſtood long enough to allow the precipitate all to ſubſide, I poured off the clear, and found ſome grains of calcareous earth, which efferveſced violently with ſpirit of vitriol.

AND thus was the theory of Dr. *Black* placed beyond the reach of contradiction; ſince we muſt here be convinced, from what

 is

previouſly wound about with ſoft leather, in order to prevent the eſcape of the factitious air.

But a very ingenious friend, *William Deane*, Eſq; who is remarkable for his ſkill in every part of natural philoſophy, but particularly mechanics, improved it further, by contriving the machine in fig. V. In the neck of the bottle A, which is the recipient, there is an *air-valve*, which allows the air to paſs into the bottle, but prevents its return; and this I found greatly to ſhorten and facilitate the proceſs.

is ſeen to paſs before our eyes, that the quick-lime became *ſoluble* in water from the want of its fixed air, becauſe we find it grow *inſoluble* the moment the *cementing principle* is reſtored.

FINDING, by the preceding experiment, that the lime, though ſo minutely divided, and ſo intimately mixed with the water, as to be reduced to a ſtate of actual fluidity, might nevertheleſs be rendered ſolid, and brought immediately into view, by reſtoring the cementing principle, I began to think, that the ſulphur in the natural ſulphureous waters might alſo be rendered viſible, by introducing air into them in like manner, as I had done into the lime-water.

BUT as I could not immediately procure a natural ſulphureous water, I reſolved to try the experiment with an artificial one.

EXPERIMENT 2.

IN order to do this, I boiled up ſome flowers of ſulphur with water and quick-lime (as directed for preparing the *ſulphur præcipitatum*;) and having filtered the ſolution, I put about four ounces of it into the phial uſed in the foregoing experiment, and transferred the air from an effervеſcent mixture contained in the other phial.

THE ſulphureous did not ſo ſoon loſe its tranſparency as the lime-water, but, in eight or ten minutes, a ſcum formed on the ſurface; and the whole ſolution immediately after be-

coming

coming turbid, I could plainly perceive the ſolid particles collecting themſelves together.

WHEN I thought that there was a ſufficient quantity of air thrown in, the phials were ſeparated, and the turbid contents of the firſt one poured into a tall drinking-glaſs. The liquor now ſent forth the ſtrong and peculiar ſmell which ſolutions of ſulphur always yield, when an acid is added to them.

EXPERIMENT 3.

HAVING ſoon after got ſome bottles of the *Lucan* * water, a few ounces of it were put into the phial, and air transferred from an effervescent mixture, as in the two preceding experiments; but notwithſtanding a ſlight degree of milkineſs appeared at firſt, yet no precipitation enſued.

THESE experiments, however, pointed out a method of making a pure ſolution of ſulphur, which being diluted to the proper degree, gives an artificial ſulphureous water, perfectly reſembling the natural, as to taſte, ſmell, tranſparency, and want of colour, and not liable to grow turbid on the addition of acids, which all other artificial ſolutions of ſulphur, hitherto known, conſtantly do.

EXPE-

* A village within ſix miles of *Dublin*, and the ſeat of *Agmondeſham Veſey*, Eſq; in whoſe gardens there is a ſpring of ſulphureous water; the ſpring breaks out ſo cloſe to the ſide of the *Liffy*, that it was conſtantly overflowed upon every riſing of the river, and conſequently was loſt to the public, until the proprietor, not only cauſed the well to be incloſed at a conſiderable expence, but alſo laid open a free paſſage to it through his very elegant improvements.

EXPERIMENT 4.

THE turbid ſolution of lime and ſulphur, as hath been already mentioned, was poured into a tall glaſs, and happening not to be thrown out, I found, after ſtanding thirty-ſix hours, that it did not become limpid, though I could plainly perceive a quantity of lime lying at the bottom, while the yellowiſh fluid remaining above, evidently ſhewed to be an equable and true ſolution of ſulphur, now left perfectly alone in the water: * I immediately ſaw that there was nothing more to be done here than to dilute this ſolution to a proper degree, and that it would then conſtitute a true ſulphureous water.

UPON trial, it actually did ſo; and although this preſent ſolution, from being ſo long expoſed to the open air, had loſt much of the ſtrong and peculiar ſulphureous ſmell, yet I found, on repeating the experiment, that a ſolution, freſh-made, and the lime, immediately ſeparated from it by the introduction of air, and then diluted, ſo as to leave the liquor colourleſs and tranſparent, yielded a water ſo nearly reſembling the natural, that, as to ſmell, taſte, or appearance, it was hard to perceive any difference.

BUT

* *Sulphur* was formerly thought to be poſſeſſed of great virtues: if any one ſhould now be deſirous of trying it, here is a method ſhewn whereby it may eaſily be exhibited in pure ſolution.

BUT upon dropping *lixivium tartari* into the artificial water, it inſtantly grows turbid;* whereas, when the like addition is made to the natural ſulphureous waters, their brightneſs is improved; which ſhews that the ſolution of ſulphur, in the natural waters, is brought about in ſome manner not analogous to that in the artificial; for it ſeems pretty obvious, that the ſulphur is here rendered ſoluble in water, from being deprived of its *cementing principle* by that ſhare of the quick-lime which remains undiſſolved in the boiling.

This conſideration preſented a new theory concerning the ſolubility of oil, when combined with the cauſtic alcali, and made into ſoap; which, I conjectured, might, as well as the ſulphur, be rendered ſoluble in water, becauſe the coheſion of the oily particles is deſtroyed, from the loſs of their fixed air, which is abſorbed by the cauſtic lixivium.

EXPERIMENT 5.

THIS conjecture was found to be right, by transferring air, from an efferveſcent mixture, into a ſolution of common ſoap; for the moment the air mixed with the ſolution, the oily part

* On mixing the fixed alcali, the peculiar ſulphureous ſmell is inſtantly changed to one which is rather more diſagreeable, and though the mixture becomes turbid, yet no precipitation enſues; the ſulphur and the alcali, joining into a ſort of thick cloud, remain ſuſpended in the middle of the glaſs.

part began to ſeparate, and, in a few minutes, all roſe to the ſurface, the cementing principle now being reſtored to the diſunited particles of the oil.

I REPEATED this experiment on a ſolution of ſoap, which, was filtered, and kept above a week after it was made; ſo that there could be nothing of a ſpontaneous ſeparation in either caſe.

IF the reader be well acquainted with Dr. *Black*'s theory, he can be at no great loſs in accounting for the manner in which common ſoap lees come to acquire the cauſtic quality; but if he has not ſeen the paper on *Magneſia* it will be neceſſary to inform him, that when quick-lime is added to a lixivium of pot-aſh, or kelp, it abſorbs the fixed air from theſe ſalts; but the particles of lime, by this abſorption, becoming incapable of ſolution, fall to the bottom, and leave the ſaline particles alone in the lixivium, and deprived of their fixed air: The lixivium now becomes a powerful abſorbent of fixed air, and will attract this principle from any animal or vegetable ſubſtance to which it may chance to be applied; hence of courſe it becomes a cauſtic, by corroding and deſtroying the texture of theſe ſubſtances, whoſe ſoundneſs and perfect coheſion depend on the preſence of the fixed air.

BY adverting to this theory of the cauſtic alcali, we may perhaps be enabled to ſpeak intelligibly concerning that diſſolution of the blood which ariſes from a putrefactive acrimony,

mony, and may form ſome idea of the manner in which it may be reſtored to a ſtate of ſoundneſs, from being ſupplied with a ſufficient quantity of fixed air.

IN the compoſiton called ſoap, we ſee, that the particles of cauſtic alcali, on account of their powerful attraction or affinity with fixed air, abſorb this principle from the oily particles, deſtroy their coheſion, and thus render them ſoluble in water.

Now chemiſtry ſhews, that the blood conſiſts of oily, earthy, ſaline, and aerial particles, diſſolved and mixed in a watery fluid.

I SAY diſſolved and mixed, for the oily, earthy, ſaline, and aerial particles appear to be held partly in a ſtate of mixture, and partly in a ſtate of diſſolution.

IT is through the intervention of the *ſaline* particles, that the *earthy* and the *oily*, come to be intimately united with, and in ſome meaſure diſſolved by the *watery* part of the blood; but as the aerial particles (whoſe proper uſe is to produce coheſion) prevent a *total* diſſolution of the *earth* and the *oil*, the blood, and moſt other animal fluids, while in a ſound ſtate, have a certain degree of tenacity, and feel ſmooth and mucilaginous; but when an unuſual proportion of the *fixed air* is detached and withdrawn from theſe fluids, their *ſaline* part is *then* left in a *cauſtic* ſtate, which will *now* join *cloſely* to the *oily* part, and with it form a compound which will *totally* diſſolve in the aqueous part, and thus render acrid, and thin,

the fluid that before was ſmooth, mild, and tenacious.

If to a fluid thus diſſolved the fixed air be ſufficiently applied, the tenacity and conſiſtence of that fluid will be reſtored, in the ſame manner as the particles of oil were ſeen to recover themſelves, on air's being transferred into ſolutions of ſoap.

The foregoing experiments opened the way to ſome improvements in *pharmacy*; ſince it followed plainly, that if oil may be rendered ſoluble in water by depriving it of the fixed air, *camphor*, and all kinds of *reſinous bodies*, may, on the ſame principle, be diſſolved. *

EXPERIMENT 6.

I began with the camphor, and having rubbed a drachm of it with an equal portion of quick-lime, and then poured on ſix ounces of lime-water, I allowed the mixture to ſtand for

* Until within a few days before theſe papers were ſent to the preſs, I looked on the method of diſſolving reſinous bodies by the means of quick-lime, as a diſcovery, not having obſerved, when I firſt read Dr. *Lewis*'s *Materia Medica*, that its diſſolvent power, with reſpect to theſe ſubſtances, is known to that ingenious and uſeful writer. The paſſage relating to this matter is under the head of *calx viva*, and runs in the following words.

" Lime-water diſſolves, by the aſſiſtance of heat, mine-
" ral ſulphur, vegetable oils and reſins, and animal fats;
" it extracts in the cold the virtues of ſundry reſinous and
" oily vegetables, and diſſolves thick phlegm, or mucous
" matters, and the curd of milk, with which laſt it forms
" a white liquid, nearly ſimilar to milk in its natural ſtate."

for half-an-hour, that the groſs and inſoluble part might ſubſide; the clear was then paſſed through a filter, and found to be a ſtrong ſolution.

ON another occaſion, I made uſe of heat, boiling the camphor and quick-lime with water in a cloſe veſſel, and thus obtained a much ſtronger ſolution.

THESE ſolutions, when filtered, are perfectly limpid, and never part with the camphor; for though the lime may be precipitated in ſeveral ways, yet I have not hitherto hit upon any method of ſeparating the camphor from the water.*

EXPERIMENT 7.

MYRRH, *gum guaicum*, *aſa fætida*, *aloes*, *caſtor*, *balſam* of *Tolu*, with *maſtich*, *jalap*, and the *cortex*, were all tried in the ſame manner as the *camphor*, and were found to yield ſtrong ſolutions and tinctures; the lime enabling the water to take up the ſame part of theſe ſubſtances that may be diſſolved by the means of ardent ſpirit. But theſe aqueous tinctures muſt be much more elegant medicines, and perhaps may be found more efficacious than the ſpirituous, ſince they will never become turbid, or ſeparate, on being mixed in any watery vehicle.

 THERE

* I have now (29th *June* 1766) ſome of this ſolution of camphor, which has been lying in a phial, not cloſely ſtopt, for more than two years; and yet it is ſtill perfectly tranſparent, and exceedingly ſtrong.

THERE is as much lime in all these tinctures and solutions, as there would be in the like quantity of lime-water, which bids fair to improve the virtues of some of them, and can do no great injury that I know of to any; but if it should ever be thought to do so, the lime may be precipitated by throwing in air from some effervescent mixture, as hath been already explained.

THE air, when thus thrown in, renders the solution, or tincture, quite turbid, and appears plainly to the eye at first, to reunite the dissolved particles of the resin, as well as the lime; but the former are very soon redissolved, and the lime only falls to the bottom,

BUT as this process may be thought troublesome, a solution may be made (not indeed so strong as those above-mentioned) in which there shall not be a particle of lime: as for instance with regard to camphor.

Take of camphor one drachm;
——— double-refined sugar one drachm;
——— simple lime-water one pint;

RUB the camphor and the sugar together into a fine powder, and then gradually pour on the lime-water; let the whole stand for two hours, and then pass the liquor through a filter. And thus will be produced, a much stronger solution than that in the common *julepum camphoratum*.

IN the common way of making *julepum e moscho* (as directed in the London Dispensatory) scarce any of the *musk* is dissolved; but if it be made in lime-water, a perfect solution

lution of the finer and more active part of the medicine will immediately take place.

Take of muſk one ſcruple;
—— double-refined ſugar one drachm;
—— lime-water ſix ounces;

RUB the muſk and the ſugar together, then add the lime-water, and filter, as before directed.

TO this, as well as to the foregoing, the preſcriber may add any ſpirituous water, or the volatile alcaline ſpirits, without deſtroying the tranſparency of the ſolution.

IF an acid ſpirit be poured upon what is left on the filter, after either of the foregoing ſolutions, it will be found to raiſe a ſmart ebullition; which plainly ſhews that the quick-lime that was diſſolved in the water is now ſaturated, and rendered ſolid, by the *cementing principle*, and has changed places with part of the camphor and muſk, which remains diſſolved in the water, while the lime is precipitated.

BUT there are caſes wherein the lime will bid fair to improve the virtues of the reſinous ſolutions; as, for inſtance, when the *cortex* is preſcribed merely with a view to its aſtrictive quality, as in ſcrophulous and relaxed habits, in order to check or dry up ulcers, gleets, or uterine diſcharges; and here it may be ordered in the following manner:

Take of Peruvian bark, in powder, two ounces;
—— quick-lime one ounce;
—— lime-water thirty ounces.

RUB

RUB the bark and the lime together, until they be thoroughly mixed; then gradually pour on the lime-water; let the whole ſtand for twelve hours, and then paſs the liquor through a filter.

AND thus will be obtained a moſt elegant, and not unpalatable tincture, which may be taken, either quite alone, or in any convenient vehicle, and in what quantity the preſcriber ſhall judge proper.

I CAN venture to aſſure the reader, from repeated experience, that the bark, given in this manner, and in the caſes above-mentioned, will ſcarce ever fail; particularly, with regard to the uterine diſcharges, when they proceed from mere relaxation and weakneſs. And where a yet ſtronger aſtringent is required, oak-bark, managed in like manner, has been found to anſwer exceedingly well.

RHUBARB, prepared in the ſame manner, yields a beautiful tincture, which hath been found of great ſervice in all caſes where ſmall quantities of this root are given with a view to ſtrengthen the bowels, and to preſerve them free from a load of viſcid ſlime, as in weak and ricketty children; and in caſes, where it is ſuſpected, that the meſenteric glands are ſtuffed up and obſtructed.

ALOES, when joined with the lime, is not near ſo nauſeous as when diſſolved in the common way; and therefore, independent of the lime, whoſe virtues as an anthelminthic are conſiderable, bids fair to be of great uſe; for children,

children, who generally are the patients in these cases, will probably be induced to take the medicine better when thus made up, than when it is prepared in the usual manner.

MYRRH and *saffron* may be occasionally joined with *aloes*; and being all dissolved by the means of quick-lime, will make an efficacious *elixir proprietatis*, as the lime will certainly improve the virtues of the other ingredients, in most cases where a composition of this sort may be ordered to advantage.

GUM GUAICUM may be dissolved with great ease, in the manner we are now speaking of, being rubbed up with an equal quantity of quick-lime, and afterwards mixed with the requisite proportion of lime-water. This solution, as it mixes so completely with any watery vehicle, can be much easier taken, and perhaps may be found a more powerful medicine, in cold rheumatic complaints, than the common tinctures: *Castor* answers exceedingly well, given in this manner, and may be taken in large doses, without offending the stomach.

Two drachms of *castor*, rubbed up with a drachm of quick-lime, and mixed with six ounces of lime-water, give a strong and elegant tincture, which may be flavoured by adding nutmeg-water, or any other of the like sort, and then given in such doses as shall be thought convenient.

IT will, no doubt, be reckoned superfluous, that *lime-water* is ordered to be added to these several

ſeveral ſubſtances, when they are alſo to be rubbed along with *quick-lime* ; but the reaſon is this : If the lime were ſo quick and freſh as to raiſe heat when common water is poured on it, the ſolution might then be made without the aid of lime-water ; but as it will, for the moſt part, happen that the lime kept in the ſhops ſhall not be perfectly freſh, it will be beſt that the preſcriber ſhould direct lime-water to be uſed, in order to be ſecure of the ſolution, which would not be ſo completely made, nor ſo much of the reſinous ſubſtance be diſſolved, if *ſlaked lime* and *common water* only were made uſe of.

AND it is much the ſame thing in the end, with regard to the proportion of lime in the ſolution; for although lime-water may receive ſome additional ſtrength, from being poured repeatedly on freſh quick-lime, yet here the quantity acquired muſt be ſo very inconſiderable as not to be worthy of notice.

As the fixed air, when thrown off by putrefaction, or during the firſt ſtage of fermentation, equally produced the effect, of rendering *mild* the *cauſtic* alcali, with that which was ſet free by effervefcence ; it might have been fairly concluded, that it would alſo precipitate the lime from lime-water ; but as I had laid it down for a rule to depart as little as poſſible from actual experiment, and to be very ſpa-
ring

ring in drawing conclusions from any thing but evident facts, I determined to make the trial.

EXPERIMENT 8.

ACCORDINGLY, having joined two phials together, by means of the bended glass tube, (as in the 16th experiment of the second essay), and filled one with fresh mutton, and a little water to make it putrefy the sooner, and the other with lime-water, I laid them by in order to let the putrefaction proceed.

BEFORE twenty-four hours were elapsed, the precipitation of the lime was evident, and it increased every day, for six days that the phials remained in this situation; but shaking the phials one day, in order to make the putrid liquor subside (for it rose in the tube in the same way that it did in the experiment before-mentioned, when I was transferring air from putrid flesh into the caustic alcali) the tube happened to break, and an end was thereby put to the experiment; but I had seen enough to prove that *fixed air*, when thrown off by *putrefaction*, would produce the very same effect on lime-water with that which was set free by *effervescence*.

AND here we have an additional proof of the *fixed air*'s being the *cementing principle* in *animal substances*; since we *see*, that while the flesh is resolved, and falls in pieces, from the

loss

loſs of this principle, the lime is rendered ſolid by having it reſtored.

WHILE this experiment, and the following, were going on, I filled two phials with filtered lime-water (that uſed in the experiments was always filtered) and left one of them without a cork, while the other was cloſely ſtopped, and laid them by as ſtandards; to ſee if any of the lime would precipitate when left to itſelf: But neither the one, nor the other, in a fortnight's time, depoſited the ſmalleſt particle of lime.

EXPERIMENT 9.

IN order to try the effects of the *gas*, or vapour, diſcharged during the firſt ſtage of fermentation, I made up ſix ounces of a fermentative mixture, of fleſh meat, bread, cabbage, and turneps, with the requiſite quantity of water, and put it into one phial; which being joined, by means of the tube, to another filled with lime-water, the two were placed in a temperate degree of heat, that the mixture might ferment the ſooner.

THE fermentation began in the uſual time, and went on with the common appearances: And as it did proceed, the lime became every day more and more viſible; and forming, firſt, light flakes of a feathered reſemblance, near the ſurface, theſe gradually fell to the bottom, until, at the end of five days (the period that the phials remained in conjunction) when I poured out the water, and allowed the

the precipitate all to ſubſide, I collected three grains of calcareous earth from ſix ounces of lime-water, which was the quantity contained in the phial.

THIS action of the vapour (which has on former occaſions been termed antiſeptic) in re-uniting the diſſolved and ſcattered particles of lime, may ſerve to give ſome idea of the manner of its operation on diſſolved blood, when the texture of that fluid is deſtroyed and broken, by a putrefactive acrimony.

THIS experiment likewiſe ſhews, that lime-water, muſt loſe part of its virtue, from the fixed air of the alimentary ſubſtances ſaturating and rendering inert, the diſſolved and active particles of the quick-lime; and, therefore, when given as a *lithonthriptic*, ought not to be drunk, but when the ſtomach is empty.

THE activity of lime-water muſt alſo be impaired by infuſing vegetable ſubſtances therein, which contain much fixed air; ſuch as the *guaicum*, or *ſaſafras*; for theſe woods abounding in reſin, give out their cementing principle, which, uniting with the diſſolved quick-lime, reſtores it to its original ſtate of an inactive calcareous earth: Therefore, when it is intended that theſe woods, or any other ſubſtance of the like nature, ſhould give out their virtue to lime-water, and that the water ſhould, at the ſame time, contain its due proportion of diſſolved lime, ſome quick-lime ought to be added, during the time of maceration.

WE have seen, then, in *three* different instances, that the lime is precipitated from lime-water by restoring to it the fixed air: May not lime-water, therefore, upon this principle, be used as a *test* to try whether or not bodies contain *fixed air?* If any body, upon mixture with lime-water, occasions a precipitation, and if the precipitate so caused effervesceth with acids, may we not conclude that the body so added contains fixed air; and that, in a greater or smaller proportion, as the precipitation of the lime from the water is more or less immediate?

EXPERIMENT 10.

SPIRITUS *cornu cervi per se*, *salt of hartshorn*, and *salt of tartar*, being severally mixed with lime-water, immediately threw down a precipitate, which, upon examination, [illegible] found to be true calcareous earth.

EXPERIMENT 11.

SPIRIT of *sal ammoniac, made with quick-lime*, and the *caustic alcaline ley*, made of pot-ash and quick-lime, when mixed with the lime-water, did, neither of them, in the least destroy its transparency, nor did any precipitation ever ensue.

EXPERIMENT 12.

BUT air being transferred into the same caustic alcalies, and lime-water then mixed with

with them, the ſame appearances followed which happened on mixing the mild alcalies in the 10th experiment.

EXPERIMENT 13.

BROWN ſugar, when mixed with lime-water, preſently threw down a precipitate, which effervеſced violently on the addition of ſpirit of vitriol; but refined ſugar (which is deprived of great ſhare of its fixed air, by the quick-lime that is uſed in refining it) when diſſolved in lime-water, did not at all deſtroy its tranſparency, and, after ſtanding twenty-four hours, threw down ſcarce any precipitate.

EXPERIMENT 14.

RECENT juices of fruits, when mixed with lime-water, deſtroyed its brightneſs immediately, and ſoon after threw down a precipitate, which effervеſced violently on the addition of ſpirit of vitriol. But fermented liquors occaſioned no immediate change, nor did any precipitation enſue until after ſeveral hours ſtanding, and this different in different liquors: * Then, alſo, the quantity of precipitate was but ſmall, the whole of the lime not being ſaturated, as the taſte plainly teſtified was done by the recent, unfermented juices.

EXPE-

* Cyder and bottled beer threw down the precipitate much ſooner than claret or port-wine.

EXPERIMENT 15.

ARDENT ſpirits † produced ſtill leſs alteration on lime-water, than the fermented liquors; but they abſorbed the air from an effervefcent mixture very readily, and, when thus charged, threw down the lime from the lime-water inſtantly on being mixed therewith.

THESE experiments all concurring to eſtabliſh lime-water as a *teſt* of the preſence, or abſence, of fixed air, I reſolved to examine ſome of the animal fluids, in this manner.

IN Dr. *Whytt*'s very ingenious eſſay on the virtues of lime-water, we find a number of experiments, made with a view of determining what things impair or deſtroy its diſſolvent power, with regard to the *calculus*; one of which plainly ſhews, that the urine contains fixed air; for when this celebrated profeſſor mixed "an ounce and a half of lime-water, "and an ounce of freſh-made urine, it imme-"diately loſt its yellow colour, and became "whitiſh and turbid, and, in a little time, a "light, white ſediment fell to the bottom, "and left the liquor above perfectly pellucid, "of a fine light lemon colour, without any "ſcum or cruſt on the ſides of the glaſs." *

† It was rectified ſpirit that was tried.
* See the Eſſay, ſect. 2. No. 8.

EXPE-

EXPERIMENT 16.

I repeated this experiment with preciſely the ſame appearances; and found, that on pouring off the clear, and dropping in ſpirit of vitriol, a violent effervеſcence enſued; plainly ſhewing, that the particles of the quick-lime, now ſaturated with the fixed air, which they had abſorbed from the urine, were returned to their original ſtate of a calcareous earth.

We have already hinted, that there is ſome danger of lime-water's being deprived of part of its virtue, from the vapour ariſing from the alimentary ſubſtances, during their fermentation in the firſt paſſages; and here we have another circumſtance which is diſcouraging, with regard to the diſſolution of the *calculus*.

By the experiments hitherto made, the *calculus* appears capable of diſſolution in *two* ways; † either by means of a ſtrong acid, ſuch as ſpirit of nitre, which acts immediately on the earthy part of the ſtone; or by lime-water, or cauſtic alcali, abſorbing the fixed air; whence, the earthy parts, deprived of what bound them together, muſt preſently fall to pieces. *

With

† In the *Mem. de l' Acad. R* for the year 1720, there is a paper, and a number of experiments, concerning the diſſolution of the calculus. Common hard well water diſſolves ſome kinds of calculi.

* Of all the various ſubſtances examined by Dr. *Hales*, with a view of determining their reſpective quantities of air, the human *calculus* was found to contain the largeſt proportion; above one half of this maſs conſiſting of *fixed air*.

WITH regard to internal exhibition, the *acid* is entirely out of the question, and the only hope of a safe diſſolvent muſt reſt on the *cauſtic alcali*, or on the *lime-water*.

THIS alcali, when combined with oil and made into *ſoap*, is not only ſo greatly obtunded thereby as to loſe much of its power, but the ſoap itſelf is ſo nauſeous, that few patients can bring themſelves to take it in a quantity ſufficient to prove of much effect; it would therefore be a happy diſcovery if any vehicle could be found out, that would properly ſheath the acrimony of the cauſtic alcali, ſo as to allow it to be taken in large and continued doſes: Poſſibly veal broth, * or a decoction of marſh-mallow roots, might be found to anſwer this purpoſe; and lime-water might be taken at the ſame time, which would not at all interfere with the operation of the alcali, but rather add to its activity.

FOR lime-water, when taken alone, muſt often fail in producing any conſiderable effects as

* There is a paper in the Gentleman's Magazine for October 1763, which proves very plainly, that a noſtrum, exhibited by one Dr. *Chittick*, and which is found, after a perſeverance of ſome months, actually to diſſolve the ſtone, is nothing more than the cauſtic alcali, given in veal-broth. The patients prepare the broth themſelves, and ſend it to the doctor every day, who returns it with the medicine mixed therein.

[See Mr. *Blackrie's Diſquiſition on medicines that diſſolve the ſtone.* This Gentleman, who it ſeems was author of the paper above-mentioned, has now traced Dr. *Chittick*'s noſtrum to its ſource, and plainly ſhews it to be what was originally ſuſpected.]

as a *lithontriptic*, becauſe it will loſe much of its power, not only from the vapour it meets with in the firſt paſſages, but likewiſe from the fixed air of the urine itſelf, which will ſaturate great ſhare of the quick-lime, even when it hath reached the bladder.

EXPERIMENT 17.

The *perſpirable matter* alſo contains fixed air: Three ounces of filtered lime-water being put into a phial, and a funnel fixed cloſe into the neck of it, I blew in my breath through the funnel, and by the time I had continued ſo doing for ten or twelve minutes, I found the water growing turbid, and the lime becoming viſible.

THIS being a tireſome kind of operation, I deſiſted, when I had thoroughly ſatisfied myſelf that the perſpirable matter, if thrown in in a ſufficient quantity, would ſaturate all the lime, ſince even what I had done, was found, upon collecting the precipitate, to have thrown down more than a grain.

I FOUND alſo that *ſweat* contains fixed air, and uſed the following method of collecting ſome drachms of this fluid.

EXPERIMENT 18.

HAVING often obſerved hackney-chairmen ſweat ſo profuſely after ſetting down their fare, that they ſweep it off from their bare heads in

a full ſtream with their leathern ſtraps. I took an opportunity one day of collecting about two drachms of ſweat, that had been raiſed in this manner, and having mixed it with ſix drachms of lime-water, found that the mixture immediately became turbid, and, in a ſhort time, depoſited a light ſediment, ſuch as was thrown down from the urine, and which effervefced as violently when ſpirit of vitriol was added.

THUS we ſee, that the air is thrown off from the fluids by urine, and by perſpiration.

BUT the *ſaliva* ſeems as if it contained little or no fixed air; for when Dr. *Whytt* infuſed a piece of *human calculus*, weighing three grains, in a mixture of *ſaliva* and lime-water, in the proportion of one of the former, to two and a half of the latter, in two days warm digeſtion, the bit of *calculus* was reduced to one grain and a half. *

THAT is to ſay, the lime-water having ſcarce any thing of its power, the *calculus* diſſolved as readily, in a mixture of *ſaliva* and lime-water, as it would have done in lime-water alone, equally dilute; for had the *ſaliva* abounded in fixed air, which would have ſaturated the quick-lime of the water, its diſſolvent power would have been proportionably weakened, as we find it was by mixing freſh vegetable juices, or honey, with lime-water. †

* Sect. 4. No. 21.
† See Dr. *Whytt*'s Eſſay, ſect. 6 & 7, No. 34, 36, 37, & 38.

EXPE-

EXPERIMENT 19.

Two drachms of *ſaliva* being mixed with ſix drachms of lime-water, the mixture did not grow turbid; but in two hours I found a ſediment, which, on pouring off the clear, and dropping in ſpirit of vitriol, ſhewed little or no ſigns of ebullition. Hence I concluded, that this ſediment was ſcarce any thing more than the groſs part of the *ſaliva*, which, when left to itſelf, in a little time depoſites a conſiderable portion of thick and viſcid matter.

EXPERIMENT 20.

I THEREFORE reſolved to repeat the experiment, and having collected near an ounce of *ſaliva*, from a perſon in full health, and ſuffered it to ſtand long enough for the thick part to ſubſide, I then mixed two drachms of the clear with ſix drachms of lime-water, and found it produce no immediate alteration.

BUT two drachms of the ſame clear *ſaliva* being put into a ſmall phial, and air transferred into it from an effervefcent mixture, and then mixed with ſix drachms of lime-water, inſtantly the mixture became turbid, and a large quantity of precipitate, in the form of flakes, fell to the bottom, and effervefced violently when ſpirit of vitriol was poured on it.

THE firſt mixture of lime-water and *ſaliva*, after ſtanding twenty-four hours, was covered with

with a cruſt, and found to have depoſited but a ſmall quantity of whitiſh viſcid matter, which effervеſced but ſlightly with the acid ſpirit.

So that the *ſaliva* naturally contains very little fixed air, but, nevertheleſs, is a powerful abſorbent thereof. *

FROM another experiment of Dr. *Whyt*'s, the bile appears to contain as little fixed air as the *ſaliva*; for when he immerſed a fragment of *calculus*, weighing three grains, in an ounce of cyſtic bile, and three ounces of oyſter-ſhell lime-water, and kept it in a moderate heat for forty-two hours, he found that near a grain and a half of the ſubſtance of the *calculus* was diſſolved in the form of thin whitiſh ſcales. †

EXPERIMENT 21.

As I could not, at this time, procure any freſh human bile, and excepting it were freſh and taken from a healthy ſubject, the experiment would not have been fairly made, I was obliged to try that of a dog: One of theſe animals being therefore killed, and its gall-bladder

* We had a former proof of the affinity between ſaliva and fixed air, in the 11th experiment of the ſecond eſſay; wherein it was found, that the ſaliva, when intimately mixwith an animal ſubſtance, has ſome degree of antiſeptic power; which agrees with the general theory concerning this power, as laid down in the third eſſay: For *ſaliva*, being an attracter of fixed air, when mixed with an animal ſubſtance, unites itſelf with the fixed air of that ſubſtance, and in this manner reſtrains, for ſome little time, the flight of the cementing principle.

† Sect. 4. No. 22.

bladder taken out, about a drachm and a half of bile was found in the cyſt.

ONE half of this quantity being mixed with three drachms of lime-water, the mixture remained tranſparent, and equable, for an hour; it then loſt its pellucidity, and gradually depoſited a light ſediment, of a dark yellow, or rather orange colour. When it had ſtood twenty-four hours, I paſſed the mixture through a filter, in order to ſeparate the ſediment; which being done, ſpirit of vitriol was poured on, and found to raiſe a ſlight degree of efferveſcence.

THE other half of the bile was put into a ſmall phial, and air transferred into it from an efferveſcent mixture, as had been done in regard to the ſaliva, and then it was mixed with three or four drachms of lime-water.

THERE was very little difference between the appearances of this mixture, and thoſe of the former one: It remained tranſparent for about the ſame ſpace of time, and then, like the other, loſt its brightneſs by degrees, and depoſited a ſediment, which only differed in regard to the colour, being of a more light yellow. When this ſediment was examined, after ſtanding twenty-four hours, it was found to efferveſce violently with the acid, whereas the ebullition of the other ſediment was but obſcure.

FROM theſe experiments (if the lime-water be a true teſt) we ſee, that *bile* contains ſomewhat

what more fixed air than *saliva*, and does not absorb this element so powerfully. *

Perhaps, it is on this circumstance, that the power of these fluids with regard to their dissolving fat or oily matters depends; since they may thus be enabled to *absorb* the *fixed air* from the oils exposed to their action, and thereby destroying the bond of union between the oleose particles, render these bodies miscible with water.

There is an obvious reason, why the *saliva* should be the more powerful absorbent of the two; for had not the oily part of our food, from its admixture with the *saliva* in mastication, been render miscible with the watery part, the alimentary mixture could not have fermented properly when received into the stomach; the consequence of which would been sickness, nausea, and heart-burning †, from the sharpness of the oil, now become rancid by the mere heat of the place.

But when all the discordant parts of the alimentary mixture are blended together, by the disolvent power of the *saliva*, and further united by the same quality in *the succus gastricus*,

* As the *bile*, in a *sound state*, contains so little *fixed air*, we immediately see the reason why *putrid bile*, and the spirit distilled from it, raise little or no ebullition with *acids*, notwithstanding the other marks of the *alcali* in that fluid. See the *Essai pour servir a l' Histoire de la Putrefaction*, for a number of experiments tending to explain the true nature of the bile.

† Not the heart-burning attended with acid, but that accompanied with nidorose, eructations.

gastricus, *bile*, and *pancreatic juice* (fluids that are found to be of the ſame nature with the *ſaliva*) then no ſeparation of oil enſues, but the fermenting motion goes on, kindly and regularly, until new combinations take place, and that every particle of the food is broken and changed.

BUT in ſome conſtitutions this abſorbent power of the digeſtive fluids is ſo greatly weakened (or, in other words, they contain much fixed air, when, in a natural and healthy ſtate, they ought to contain very little) that the food is never thoroughly diſſolved, nor its oily part ever completely mixed or ſubdued; and hence the immediate cauſe of indigeſtion, rancidity in the ſtomach, and extraordinary flatulence.

As a proof of this, it may be obſerved, that lime-water is an excellent remedy for the complaints juſt now mentioned; and perhaps the relief which is obtained in theſe caſes from the uſe of certain medicinal waters may ariſe, in great meaſure, from their containing earthy matters void of fixed air, and which have an abſorbent power like what is obſervable in lime-water.

THESE waters, which may be conſidered as a kind of natural lime-waters containing a conſiderable portion of earthy matter *void of fixed air* (like the particles of quick-lime diſſolved in lime-water) as ſoon as they come into contact with bodies containing much of the cementing principle, muſt neceſſarily depoſit their earth,

earth, which by attracting the fixed air acquires solidity, and will form a succession of crusts, or layers; and it is in this manner, that, I think, we may form a plausible theory for petrification,* and for the crusts that are found in the pipes and vessels containing certain kinds of waters.

THESE

* A petrifaction that I have met with, since writing the above, seems to confirm this *hypothesis*.

It is a petrified moss, wherein may be observed, very distinctly, the several gradations from absolute stone to the living vegetable; the course of the fibres being every where plain, and easy to be traced. The part of the petrifaction that lay constantly under water is absolute stone, and is of the calcareous kind, effervescing strongly with acids; in the middle part, which was not so continually exposed to the action of the water, the petrifaction is incomplete; and at the top, which was always above water, the vegetable is still alive, and in its natural state.

The well from whence this petrifaction was brought being in the neighbourhood of *Dublin*, I sent for some bottles of the water, in order to examine it.

On dropping a little of the filtered solution of *pot-ash* into a glass of the petrifying water, it immediately lost its brightness, turned milky, and, in a few hours, deposited a white sediment, which effervesced strongly with spirit of vitriol.

The very same appearances happened when *Lixivium Tartari* was dropt into the petrifying water.

On air being transferred into some ounces of the petrifying water, it lost its brightness, and, in twelve hours, let fall a small quantity of white sediment.

Hence it appeared, that the petrifying water did contain an earthy matter dissolved therein, *void* of *fixed air*, which was capable of resuming the solid form, as soon as the cementing principle was restored.

Vegetable bodies, therefore, by remaining long exposed to the action of such kinds of waters, will have their substance

THESE petrifying waters were formerly condemned, as being apt to create the ſtone, but later experience has ſhewn, that the waters which abound moſt in this earthy matter, and which form the greateſt abundance of the cruſts above-mentioned, are the moſt effectual diſſolvents of the ſtone, as is every day experienced with regard to the *Carlſbadt* water in *Bohemia*.

THE abſorbent quality of the *ſaliva* moreover ſhews, how apt it muſt be to lay hold of infectious *miaſmata*, which oftentimes are in reality putrid vapours, or fixed air, detached from bodies during putrefaction; and confirms what hath been frequently recommended, namely, to ſhake off infection, * and prevent

E e the

ſtance gradually diſſolved; becauſe the the earthy particles in the water attract the fixed air from the vegetable ſubſtance, and the moment they are ſaturated they acquire ſolidity, become inſoluble, and remain in the places of the vegetable particles, which are melted away.

This change of a vegetable into a foſſil ſubſtance, ſeems analogous to the change of iron into copper, which is brought about in no very long ſpace of time, by leaving iron plates in a water that is ſtrongly impregnated with a ſolution of copper in the vitriolic acid; the ſuperior attraction of the acid to iron cauſing it to ſeize this metal, and let go the particles of copper. So, in the caſe of petrification, fixed air having a ſtronger affinity with calcareous earth than it has with the vegetable ſubſtance, lets go the latter and ſeizeth on the former.

* By the precautions taken by Dr. *Lind*, and by immediate vomiting, " only *five* perſons died, from among more " than an hundred, who were ſeverally, and ſome of them " conſtantly employed, during eighteen months, in various " offices about the ſick, in *Haſlar* hoſpital;" where there conſtantly

the *miasmata* from getting into the mass of fluids by immediate vomiting; and we may likewise see, that the cautions given by authors concerning the swallowing of the *saliva*, while in the places abounding with infectious vapours are founded in reason.

IT will not appear strange that some of the animal fluids should contain so little fixed air, when we find that the *serum* of human blood seems almost void of this element.

EXPERIMENT 22.

HAVING ordered some ounces of human blood, drawn from a healthy person, to be kept until the *serum* and *crassamentum* had fairly parted, I mixed two drachms of the serum with an ounce of lime-water: No change ensued; the mixture continued transparent, and, after forty-eight hours standing, no precipitate could be perceived, while the liquor remained in the glass; but upon pouring it out, a very small quantity of white earthy matter was found at the bottom, which, however, would not effervesce with vinegar.

EXPERIMENT 23.

ABOUT two drachms of the *crassamentum* of the same blood being put into a cup with an ounce of lime-water, and left for five days, did

constantly was a great number of people ill of fevers that were highly infectious. See his *Discourse on Fevers and Infection*, paper 2d, p 74.

did neither totally diffolve, nor turn putrid; a piece of it being then taken out, and fpirit of vitriol poured on, an effervefcence enfued; the lime which had penetrated, and joined itfelf to the fixed air of the *craffamentum*, now burfting forth from every part of it, the moment the acid was applied.

So that the fixed air appears to be connected chiefly with the red globules, and with that part of the blood called by *Serac* the *lympha coagulabilis*; fince thefe two are found to compofe the *craffamentum*.

EXPERIMENT 24.

Two ounces of lime-water being put into a tall drinking-glafs, about half an ounce of blood was allowed to flow from the vein of a perfon in health, into the glafs with the water: when it had ftood fix hours, the mixture was all poured out, to about a drachm, which was fuffered to remain in the bottom of the glafs; on this fediment fome fpirit of vitriol was dropped, and raifed a fmart ebullition; the calcareous matter turning white, as it boiled up on the addition of the acid; fo that the fixed air, is eafily detached from frefh blood.

EXPERIMENT 25.

NEW breaft milk, when mixed with lime-water, in the proportion of one to three, in great meafure deftroyed the acrid tafte of the lime, yet did not caufe any feparation that

was immediately perceivable; but after standing twelve hours, the precipitation was visible, and, on pouring out the mixture, the sides of the glass were found incrusted with a calcareous matter, which, as well as what fell to the bottom, effervesced violently on the addition of spirit of vitriol.

So that milk contains a large proportion of fixed air, and consequently ought not to be mixed with lime-water, since it must necessarily take off from its activity.

DR. *Alston* observed very well, that there is scarce any thing that is usually mixed and given along with lime water, that does not, more or less, destroy its efficacy; for which reason he recommended it always to be taken alone. *

LIME-WATER, when mixed with milk of any kind, prevents it from turning sour; the reason of which is obvious, because, by absorbing and retaining the fixed air, the intestine motion is prevented, whence there can be no change of combination.

I HAVE now finished what was originally proposed; and, I hope, have satisfactorily shewn, that *fixed air* is the *cementing principle* on whose presence *perfect* cohesion depends, at least in animal and vegetable bodies; † and though

* Dissertation on quick-lime, p. 41, sect. 11.

† I have said *perfect* cohesion, for, as Dr. *Hales* observes, "Doubtless all the particles of matter whatever do in actual contact cohere; yet since it is found by experiment, "that the most solid parts of animals and vegetables yield "a vastly

though the experiments which I have made are very far from exhausting the subject, yet they certainly are sufficient to raise curiosity, and to prompt men of leisure to a further investigation of this important element; which ought not, by any means, to be confounded with the *atmospheric air*: for, excepting its being for a time capable of elasticity, the *fixed air* does not appear to agree, in any other property, with the *common air* which we breathe.

WE know for certain, that the *atmospheric air* could not immediately pervade the lime-water, or other fluids, in the manner that the *fixed air* plainly appeared to do: * This last, though perfectly elastic when first set free, yet, in a very little time, loseth its spring, mixeth with the liquid, penetrates every where, and joins with the disunited and scattered particles of the substances dissolved. †

BUT

" a vastly greater quantity of air, and less water, than the " more lax and fluid parts, it seems therefore hence reasonable to conclude, that their solidity is principally " owing, not to the water, but to the air and sulphureous particles." Vol. ii. p. 280.

* That common atmospheric air cannot immediately pervade water, is fully proved by a number of experiments, formerly made by M. *de Reaumur*. See the Mem. de l' Acad. des Sciences, for the year 1714, the 5th article of the memoirs.

† The *air* which flies off from bodies, whether solid or fluid, in the exhausted receiver of an air-pump, is *not* the *fixed air*; for this never departs but when the body to which it belongs either suffers a decomposition, or is dissolving into minute parts.

Thus, if the *mild* volatile alcali, and the *caustic* volatile alcali (*viz.* Sp. cornu cervi per se, *and* Sp. Sal. Ammon. cum

BUT a ſtill more ſtriking diſtinction between the *fixed* and the *common atmoſpheric air*, may be remarked in the very different and oppoſite effects which the two produce in the bodies of living animals.

THE *fixed air*, when ſet free, and in a ſtate of perfect elaſticity, whether it be during the firſt ſtage of fermentation, by fire, * by effer-veſcence, or by putrefaction, † if it be recei-ved

cum calce viva) be both incloſed in the ſame exhauſted receiver, the one will throw off as many air-bubbles as the other; though we certainly know that the firſt contains a large proportion of fixed air, while the ſecond is entirely void of this principle.

* Dr. *Hales* ſuffocated a ſparrow, by putting it into air that had been obtained by diſtillation from heart of oak. Vol. i. p. 176.

† Accounts of people ſuffocated by putrid vapour on going down into wells or vaults that have been long ſtopt up are extremely common; but there is one inſtance of the deleterious effect of this kind of vapour related in the hiſt. of the academy of ſciences, for the year 1745, which is very remarkable. A ſailor, on board a ſhip at *Rochfort*, having inadvertently taken out the bung from a caſk full of putrid ſea water, was inſtantly ſtruck dead, and ſix others who were in the hold, at ſome little diſtance, alſo fell down, loſt their ſenſes, and became convulſed. The ſurgeon of the ſhip, being told of the accident, haſtened to their relief; but no ſooner entered the hold, then he likewiſe fainted. However, he and the ſix ſeamen were, by ſome means or other, dragged up from the hold into the open air, where they ſoon recovered.

M. *Dupuy*, phyſician to the marine at *Rochfort*, who relates the ſtory, was deſirous of examining the body of the dead man; but it preſently grew black, puffed up, bled at the noſe, mouth and ears, and became ſo exceedingly putrid and offenſive, that it was impoſſible to proceed to the diſſection.

Thus

facing p. 215.

Fig. 5.

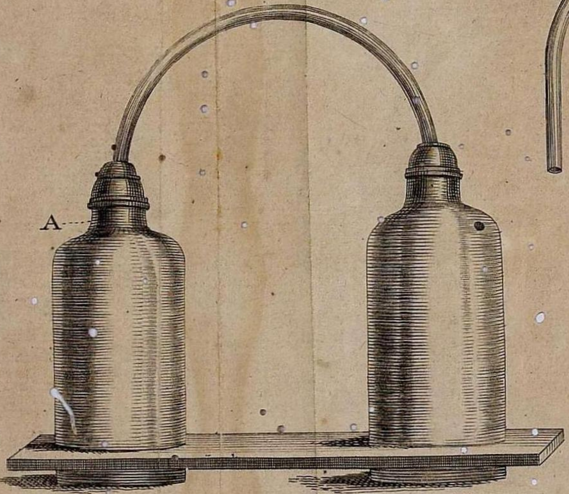
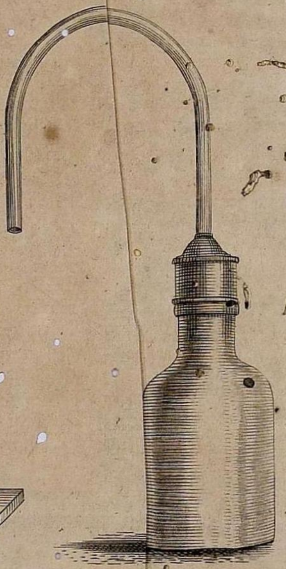


Fig. 4.



ved into the lungs of any living animal, causeth instant death.

BUT

Thus it appears that these vapours do not kill by mere suffocation, but that they act at once on the blood, and destroy its texture in a most surprising and unaccountable manner.

A very little precaution would always secure people from every accident of this fatal nature, since it requires nothing more than to fix anopen lanthorn with a lighted candle in it to a pole, or cord, and let it down, or thrust it into the plcae which there is reason to suspect may be full of noxious vapour (such are old wells, or vaults that have been long closed up; wells of ships full of stinking bilge water; cellars or vaults full of liquors, in a state of fermentation.) If the candle continues to burn, people may enter with safety; but if it goes out immediately on being exposed to the noxious vapour, then no person must on any account go in, until the vapour be dispersed, either from the place's being left open for a proper length of time, or by repeatedly throwing in lighted squibs or crackers, which, by their explosion, will presently purify the air.

The following experiments, made by my ingenious friend, Mr. *James Kenley*, of *Belfast*, will very properly come in here.

Belfast, Sept. 22*d*, 1765.

"Some days ago I got four puppies, and immediately "set about the experiments you recommended, which I "made as carefully as I could.

"I thrust an awl into the medulla oblongata of one of "the puppies, and kept it as a standard. I killed a second "by suffocating it with fixed air, a third with the fumes "of burning brimstone, and a fourth with the fumes of "burning charcoal. I opened the thorax of each, and "observed that the lungs in the animal killed by the fixed "air appeared more collapsed than those of the animal kil- "by the awl. The lungs in both appeared exactly the "same colour. The lungs of the animal killed with the "fumes of sulphur were intirely collapsed, and of a very "white colour. The lungs of the puppy killed with the

"fumes

BUT the ſame elaſtic matter, when received into the ſtomach, whether thrown off from efferveſcent mixtures, given in the way of medicine, or extricated from the food in the natural proceſs of alimentary fermentation, is ſo far from producing any ill effect, that, in the firſt inſtance, it often operates like a charm in reſtraining vomitings, and, in the ſecond, is abſolutely

" fumes of charcoal appeared of a white colour, and quite " collapſed; the colour of the lungs in the laſt animal was " not ſo white as the former. I could not procure a fifth " puppy, or would have ſuffocated in it its own vapour, and " obſerved whether the lungs differed in appearance from " any of the others or not.

" Having obſerved that Dr. *Hales* could breathe air " which paſſed through cloths dipt in vinegar (ſtatical eſ- " ſays, p. 263) much longer than the ſame quantity of air, " without ſuch cloths, I imagined that the air in a fixed " ſtate might in ſome way or other be deprived of its acid, " and then loſe its vivifying power, or ſpirit, as it is called. " In order to know whether animals could breathe fixed air " longer with acids ſuſpended in it, I made the following " experiments.

" I incloſed a ſparrow in a bladder, the mouth of which " was well tied to one of the legs of your air-machine. I " transferred the air of ſome pearl-aſhes into the bladder; " the bladder was immediately diſtended, and ten minutes " after the ſparrow died.—I incloſed a ſecond ſparrow in a " bladder, and tied it as before; but in this I ſuſpended a " piece of ſpunge dipt in vinegar. I charged the bladder " with fixed air, and obſerved that the ſparrow lived near " half an hour.—I incloſed a third ſparrow, and a piece of " ſpunge dipt in equal parts of volatile vitriolic acid and " water as before; the bladder was then charged with " air; the ſparrow lived for 43 minutes.—I incloſed a " fourth ſparrow, and dipt the ſpunge into equal parts of " Glauber's ſpirit of nitre and water; the ſparrow lived " for half an hour."

abſolutely neceſſary for the ſupport of life and health.

WITH regard to the *atmoſpheric air*, it is univerſally known that *no* animal can live long without freſh ſupplies of it, and thoſe who have lungs cannot exiſt many minutes without taking in large quantities of this element. But if a very ſmall portion of the ſame be forced into the veſſels and mixed with the fluids of any living animal, death preſently enſues.

So that theſe two elements ſeem to be different in their natures, and to have quite diſtinct provinces with regard to animal life: We have not, as yet indeed, a ſufficient number of facts to determine *poſitively* whether they be *originally diſtinct elements* in nature; or whether the *fixed air* is nothing more than a portion of the *univerſal aerial fluid*, which is altered, and modified, from its having been united with ſome other principle.

THIS ſeems to have been the opinion of Dr. *Hales*, who looked on fixed air as a portion of the common atmoſpheric elaſtic air, deprived of its ſpring, and reduced to a ſtate of fixity and attraction, by the power of the *ſulphur principle* in bodies.

BOERHAAVE was in ſome doubt what to think concerning the fixed air. "Dubitatum "quandoque, an omne illud quod ita gigne-"retur foret quidem ejuſdem ita naturæ ut eo-"dem nomine aeris elaſtici appellari debet? "an vero, corpora certa lege reſoluta in partes "minimas, omiſſa natura ſua prima, forte ve-

" ra transſmutatione permutarentur in aerem
" hunc elaſticum, qui dein rurſum concretus
" aliis iterum firma redderet nova corpora ?
" an adeoque præter aerem communem elaſ-
" ticum, aliud illi ſimile, non idem, in rerum
" natura obtineret ?" *Element. Chem.* tom. i. p. 532.

BUT let the original nature be what it will, it appears, from a circumſtance peculiar to lime-water, that there is great ſtore of the *cementing principle* always floating in the atmoſphere, which is ready to be abſorbed by ſuch bodies as have an affinity therewith; for we ſee that the particles of the diſſolved quick-lime, which are neareſt the ſurface of the water, attract the fixed air from the atmoſphere, and form cruſts, which are nothing more than a pure calcareous earth, ſuch as the quick-lime was before calcination, and which by the action of fire, may be reduced to quick-lime again.

SUPPLE-

SUPPLEMENT.

IT having been laid down by Dr. *Hales* that air is the bond of union in ſalts, and the ſame thing having been aſſerted by the baron *de Haller* (ſee the paſſage tranſcribed from him in the note at the beginning of the ſecond eſſay) I took it for granted that it really was ſo, and in the former edition, when accounting for the difference between the ſpirit of *ſal ammoniac* made with quick-lime, and that which is made with chalk, I alledged that the quick-lime detained the fixed air of the crude ſalt as well as the acid, whence the volatile ſpirit obtained by the diſtillation could neither effervеſce, nor the volatile ſalt put on the concrete form: But I now find that this theory will not anſwer, ſince it appears from experiment, that crude *ſal ammoniac* contains no fixed air; for having thrown a drachm of this ſalt (previouſly rubbed into a powder in order to make it diſſolve quickly) into an ounce and a half of clear lime-water, the ſolution did not at all abate of its tranſparency, and not the leaſt ſign of precipitation ever enſued.

I ALSO find that *common ſalt* does not contain much fixed air, and that *nitre* has ſtill leſs of this principle.

A DRACHM

A DRACHM of *nitre* being diſſolved in an ounce and a half of clear lime-water rendered it ſomewhat turbid, and threw up a ſmall quantity of whitiſh ſcum on the ſurface; little flakes of white earth gradually formed themſelves, partly fell down to the bottom of the glaſs, and partly remained ſuſpended in the ſolution; but the whole of what earthy matter was formed did not exceed the quarter or third part of a grain.

A DRACHM of *common ſalt* (of the fineſt ſort, ſuch as is generally uſed for the table) being diſſolved in an ounce and a half of clear lime-water rendered it more turbid than the nitre did, threw up more of the white ſcum, and in the end let fall at leaſt double the quantity of earthy precipitate, there being about half a grain of it, which efferverſced with weak ſpirit of vitriol, as did alſo that which was depoſited by the ſolution of nitre. Now when ſalt of tartar, or ſalt of hartſhorn, which are both of them replete with fixed air, are mixed even in very ſmall quantities with clear lime-water, the ſolution inſtantly becomes turbid and very ſoon lets fall a conſiderable quantity of earthy precipitate.

FROM theſe experiments it appears, that ſaline particles do not always require fixed air to bind them together, and that ſalts may put on the concrete form with a very ſmall quantity, or even altogether without the aid of this principle.

BUT

But what is very remarkable, fixed air has the power of rendering ſaline particles incapable of remaining in a ſtate of ſolution, and of giving them ſo much ſolidity that they have the appearance of earth.

Doctor *Ferguſon* of *Belfaſt*, who has written an eſſay on the uſe of leys and ſours in bleaching, which will ſhortly be publiſhed, and which will point out ſome improvements of very great importance to the the ſtaple manufacture of this kingdom,* among other curious experiments has the following.

He diſſolved four ounces of pearl aſhes in twenty ounces of water, and after filtration laid by four ounces of the clear ley for a ſtandard; he then transferred factitious air into the remainder from an effervescent mixture, by the means of an apparatus, ſuch as is repreſented in the plate fig. 5. the ley did not begin to grow turbid till after twelve hours ſtanding; next day a ſediment was depoſited; at the end of four days he carefully collected and dried the precipitate, which weighed nine grains, and was quite inſipid: The ley was much milder to the taſte than the ſtandard, and an ounce of it was ſaturated with a fourth part leſs of an acid than was required to bring an ounce of the ſtandard to a neutral ſtate.

From this experiment we may eaſily conceive how it comes to paſs, that *volatile ſal ammoniac* may put on the concrete form, by the aid of the fixed air, which is ſupplied to it

* Ireland.

it from the chalk, when this ſubſtance happens to be uſed in the diſtillation.

HAVING ſometimes thought that fixed air might poſſibly have the power of reſtoring a metallic calx, I tried it in the following manner, but did not find it anſwer this expectation.

I MIXED two drachms of *minium* with a ſpoonful of water, and put it into a ſmall phial; the tube of figure 4 was inſerted into the mouth of this phial, and fixed there. I then expended about ſix drachms of ſalt of tartar, in tranſferring air into the mixture, but it produced no apparent change of any ſort. This being done, the mixture of minium and water was poured into an iron ſpoon, and placed on the fire; it was kept there for ſome time, even after the ſpoon grew red hot, but the minium ſtill remained in the ſtate of a calx, without any other change than what regarded its colour, for it now turned from a bright red to a dark crimſon.

HAVING allowed the things to cool, I then added a little bit of tallow, and again ſet the ſpoon on the fire; the tallow ſoon flamed and burned away, but left the greateſt part of the minium reduced to lead, and the remainder changed to a bright yellow powder.

FINIS.

POSTSCRIPT.

THE foregoing Sheets were all printed off and ready for publication, when the Author received a letter, dated *Long-reach*, *April* 9th, 1767, and a Journal from Mr. *Alexander Young*, Surgeon of his Majesty's Ship *Jason*, containing a general Account of the State of Weather and Diseases, during a Voyage to the *Falkland Islands* on the Coast of *Patagonia* together with a particular detail of four Scorbutic Cases, wherein Wort was given according to the proposal in the fourth Essay.

This Voyage was so uncommonly healthy*, that the Journal contains nothing new,

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* The *Jason*'s company consisted of 180, including twenty-five Marines, but no boys: out of this number they buried but three during the whole Voyage, from 25th of Oct. 1765, to 20th of *March* 1767. One of these died of a putrid fever, the second went off in the fit of an Apoplexy, and the third killed himself by excessive drinking. It appears indeed, from the Journal, that

new, or remarkable, except what regards the management of the Scorbutic Cafes, which are here extracted, and given precifely in the words of Mr. *Young*, who mentions in his letter, that as Seamen in general are fo very averfe to every thing in the way of experiment, he could not have prevailed on the men to take the Wort, if they had not obferved the officers drink it repeatedly, without inconvenience, by way of prefervative.

There was no opportunity of determining the genuine effects of the Wort, until the Ship was on her return home *, for the only one who drank it on the paffage out, and, who recovered, was alfo fupplied by the Captain with Apples and Oranges, and thofe who drank it for fuch Scorbutic Complaints as appeared among them, during the Winter at *Port Egmont*, likewife ufed the wild Celery, which grows there, in

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that the utmoft pains were taken, from the beginning, to preferve the people in health; once a week, the chefts were examined, to fee that every man had his ftock of cloaths, and they were obliged to keep themfelves always clean, and well dreffed, under penalty of having their allowance of fpirits ftopt; the fhip was well aired between decks, and fumigated with Tar and Brimftone, from time to time, and during the whole paffage, both out and home, Elixir of Vitriol was mixed with the water, two fpoonfuls to a puncheon.

* The *Jafon* failed from *Port Egmont* in the *Falkland Iflands*, on the 18th of *January*, and arrived in the *Downs*, on the 20th of *March* 1767.

great

great abundance, and they never took the Wort regularly, but in the following Cafes, the Patients had no aid from frefh vegetable diet.

'Their breakfaft was the Sea Bifcuit 'boiled up with Wort and Sugar; for dinner, at fometimes what could be fpared 'from the officers table, and at other 'times Portable Soup, thickened with 'Barley or Rice, and feafoned with Shallots or Garlic; for fupper, Rice and Currants, Sago, or Salep with Madeira.'

The four all began the Wort at the fame time; two of them, it appears, had been received from the *Carcafs* floop, juft before the *Jafon* failed for *England*.

'The Wort was made frefh every day, in 'the proportion of three meafures of boiling 'water to one of the ground Malt, it was 'allowed to ftand clofe covered till cold, 'and then ftrained.'

An extract from a Medical Journal, kept by Mr. *Alexander Young*, Surgeon of his Majefty's Ship *Jafon*, Captain *John M'Bride* Commander.

'*William Larder*, aged 29, formerly of a 'good habit of body.——*Feb.* 1ft, 1767, 'complains of great laffitude, that he finds 'himfelf fatigued by walking but a little 'while; his face is pale and yellowifh; his 'mouth pretty clean, owing perhaps to the 'Elixir of Vitriol we daily put in our water;

 'his

'his gums are a little ſwelled and ſpungy; his 'breath is very offenſive, his legs ſwell, and 'pit when preſſed with the fingers, they are 'covered with blue ſpots, of different ſizes 'like bruiſes, with two ulcers, which diſ-'charge a thin bloody ichor, and have a 'black mortified appearance; his legs are 'more ſwelled at night than in the morning; 'he is generally coſtive, his appetite is good, 'and his pulſe pretty regular.'

'His legs are ordered to be ſtuped with 'the common fomentation, and the ulcers 'dreſſed with the common dreſſing.'

'Gave him half a pint of the Wort in the 'morning, and half a pint in the evening.'

'3d, Gave him one pint in the morning, 'and half a pint in the evening.'

'7th, Gave him a pint morning and 'evening.'

'8th, The Wort purged him laſt night, 'but he took the ſame quantity to-day with-'out having any ſuch effect.---Finds him-'ſelf ſomething better.'

'12th, Gave him a pint in the morning, 'another in the middle of the day, and a 'third at night.'

'20th, He looks healthier, his legs are not 'ſo much ſwelled, the ulcers ſeem inclina-'ble to heal, having loſt that black bloody 'appearance.'

'Gave him a quart of Wort in the morn-'ing, a pint at noon, and another at night.'

'28th,

'28th, He finds himſelf greatly better, the 'ulcers being almoſt healed, and the ſwelling 'gone, except a little in the evening, the 'ſkin is peeling off his legs. Gave him a 'quart in the morning, one at noon, and 'one at night.'

'*March* 5th, Has no complaint, and re- 'turns to his duty, but continues to drink 'the Wort, the quantity of which is to be 'leſſened by degrees, until he leaves it off 'entirely.

'*John Carrol*, aged 35 years, formerly 'healthy; brought a Pox with him from '*England*, which has eluded the force of all 'the medicines given him, owing perhaps to 'the man's own negligence and intempe- 'rance, joined to the Scorbutic habit which 'he acquired during the winter.

'He was very ill of the Scurvy, during the 'winter, but got better by drinking the 'Wort, eating wild Celery, and uſing exer- 'ciſe on ſhore, the calves of his legs were 'quite indurated, and black at that time.'

'*Feb.* 1ſt, He has now ſeveral ulcers up- 'on him, in his legs and arms, which are 'very offenſive; a large hard ſwelling on 'his cheek; his teſticles are ſwelled, hard, 'and quite inſenſible; his gums are rotten, 'black, and bleed frequently; his breath 'ſtinks horribly; he is quite emaciated, and 'ready to faint every ſtep he takes; he has no 'appetite, is greatly dejected, and his pulſe 'very low.

'The

'The ulcers were dreſſed dry.

'Gave him half a pint of the Wort, in 'the morning, which immediately brought 'on a looſeneſs with fainting, this however 'ſoon ſtopped, on his taking ſome doſes of 'the Electarium e Scordio, diſſolved in Cin-'namon Water, together with mulled Wine. 'Gave him twenty drops of the Acid Elixir 'of Vitriol, along with his Wort; and three 'times a day, a glaſs of the following bitter 'wine.'

℞. Cort. peruvian. craſſe pulv. Uncias duas,
——— Limonum Seſcunciam,
Vini Madeirens: lib. duas. M.

'3d, He is better,——gave him half a 'pint of Wort, twice a day.

'10th, He finds himſelf ſtronger, and not 'ſo liable to faint.——The ſwelling on his 'cheek looks red and inflamed. Applied a 'poultice of oatmeal with a little oil.

'20th, Stronger,—has a better appetite, 'ulcers look better, the tumour on his cheek 'broke of itſelf, the quantity of matter but 'ſmall, blackiſh, and very offenſive. Gave 'him a pint of Wort twice a day.

'*March* 1ſt, Continues mending.—His 'cheek has degenerated into a foul looking 'ulcer like the reſt.—Gave him three pints 'of Wort in the day.

'10th, Has almoſt quite recovered his 'ſtrength, and eats heartily.—The ulcers

'begin

'begin to diſcharge a thicker matter, and
'have not ſo bad an appearance.

'16th, Continues to mend.—Gave him
'two quarts of Wort in the day.

'20th, Arrived in the *Downs*.—He is
'greatly mended in his appearance, and
'health in general.—Judged neceſſary to let
'him have the benefit of the air on ſhore.'

'*William Rogers*, Marine, aged about
'24, of a thin, weakly habit of body, has
'been ſickly all winter.

'*Feb*, 1ſt, Complains of great weakneſs,
'pain, and ſwelling of his knees, his legs
'are drawn up ſo that he cannot ſtretch them
'without pain, his face is of a dark, yel-
'lowiſh colour, he is quite emaciated, being
'ſcarce any thing but ſkin and bone, his
'pulſe low and rather quick, he is generally
'looſe.

'His knees were fomented twice a day
'with the common fomentation, to which
'was added, an eighth part of Vinegar, and
'rubbed with a camphorated Liniment. He
'likewiſe took the bitter wine, and half a
'pint of Wort twice a day.

'6th, Gave him half a pint thrice a day.

'10th, Gave him a pint twice a day.

'11th, The Wort purged him laſt night,
'but ceaſed immediately on taking twenty
'drops of Tinctura Thebaica in two ſpoon-
'fuls of Cinnamon Water.

'12th

'12th, Gave him half a pint three times 'a day.

'18th, He is much better, can ſtretch out 'his legs, and walk pretty well.—Gave him 'two pints and a half in the day.

'26th, Continues mending.—Gave him a 'pint three times a day.

'*March* 9th, Now finds himſelf pretty 'well, and is returned to his duty, but ſtill 'continues to drink the Wort, in a ſmaller 'quantity.

'*William Waters*, aged 36, a ſtrong man 'and formerly very healthy, was afflicted 'with Scorbutic complaints all winter.

'*Feb.* 1ſt, Complains of weakneſs, falling 'away in his fleſh, and ulcers in his legs, 'dreſſed the ulcers dry, and gave him three 'half pints of the Wort in the day.

'6th, Gave him a pint thrice a day.

'20th, Gave him two quarts in the day.

'28th,. Gave him three quarts in the day.

'*March* 10th, Ulcers healed up,—has no 'complaint, and looks remarkably fat and 'fair,